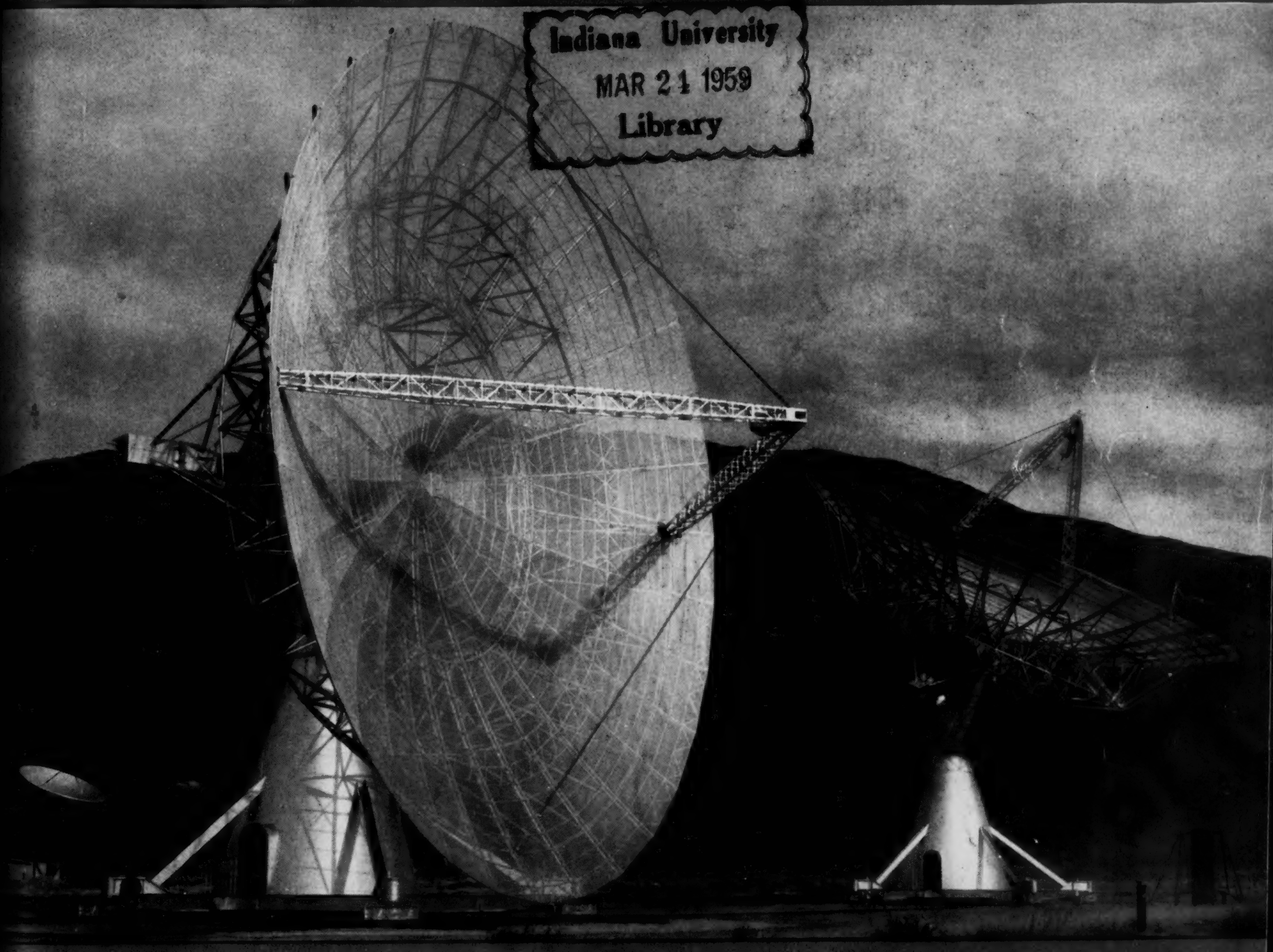
Sky and TELESCOPE



Caltech's twin radio telescopes

In This Issue:

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APRIL, 1959
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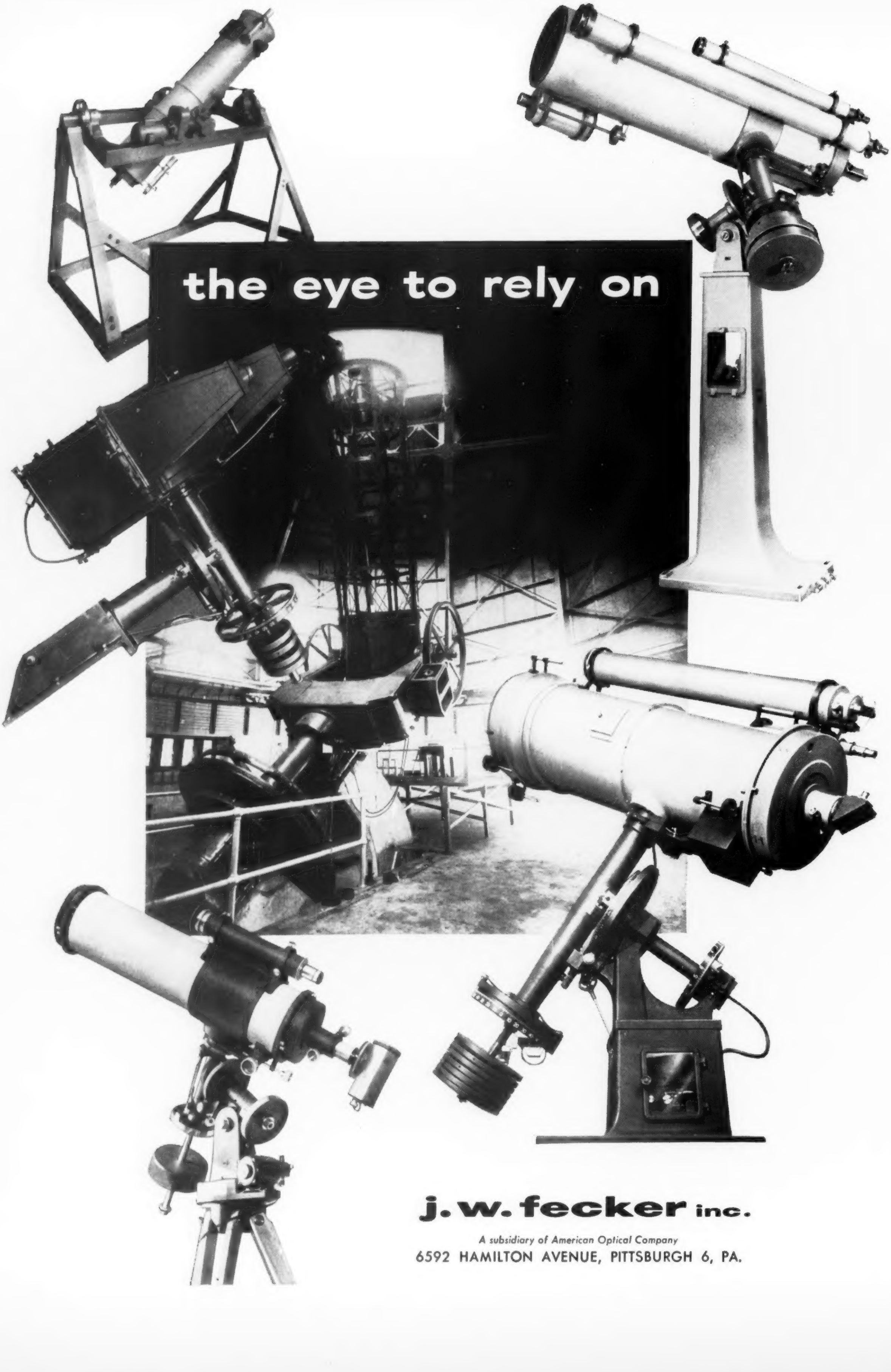
the eye to rely on

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*

JOSEPH ASHBROOK, *Technical Editor*

Vol. XVIII, No. 6 APRIL, 1959

CONTENTS

COVER: The California Institute of Technology Radio Observatory in the Owens Valley, California, near Big Pine. It has three operating radio telescopes, one with an antenna 32 feet in diameter (lower left in picture) and two with 90-foot paraboloids. The observatory's operating budget of $150,000 is financed by the Office of Naval Research, which has contributed $1,300,000 toward the development and construction of the project. California Institute of Technology photograph. (See page 302.)

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Lunar and Planetary Meetings

ALTHOUGH the term space science was virtually unknown only a few years ago, space scientists are today numbered in thousands. Among them are many engineers, physicists, and administrators in industry and government agencies who are finding that their work requires more knowledge of solar system astronomy. At the same time, astronomers need more information about missile engineering. This two-way problem in scientific communication is of great urgency.

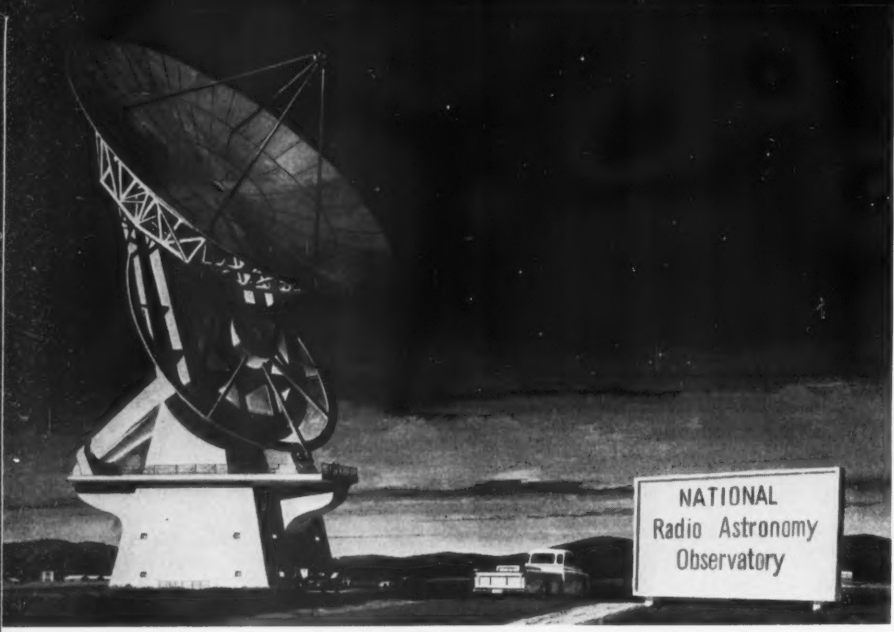
To help solve it, North American Aviation, Inc., Rand Corp., and California Research Corp. began a series of informal meetings last spring, at which about 100 experts in these fields exchanged ideas. The first three meetings were held in the Los Angeles area on May 13, July 15, and October 29, 1958. A report of each of these sessions has been published by North American Aviation, under the title *Proceedings* of Lunar and Planetary Exploration Colloquium.

Of the astronomers who are members of this colloquium, one of the most active participants has been Dinsmore Alter, the retired director of Griffith Observatory. Many of the illustrations in the *Proceedings* are samples of the beautiful large-scale lunar photographs Dr. Alter has been taking with the 60-inch Mount Wilson reflector.

The discussions have included such topics as H. C. Urey's reasons for believing that much of the moon's surface is lava-covered rather than coated with dust; R. S. Richardson's recent observations of banded markings on Venus; and F. Press' analysis of what a sensitive seismograph placed on the moon's surface might tell us about the deep interior of our satellite.

S. M. Greenfield, of the Rand Corp., sought suggestions from the group on desirable lunar experiments, to be carried out from the earth, from space vehicles, and on the moon itself. Later, questionnaires were circulated, listing the 48 suggested undertakings, and asking for their evaluation.

The projects that were assigned first priority (on the basis of scientific value, necessity as a preliminary to other work, and noncontamination of the moon) form the following list: photographic and photometric observations in all wave lengths; laboratory experiments on properties of hypothetical lunar materials, and on the formation of lunar features; space-medical studies of man in a closed environment; measurement of lunar magnetic field; determination of surface radioactivity and chemical composition; search for sub-life forms and macromolecules; biological experiments; and astrometric studies.



An artist's concept of the 140-foot dish and massive equatorial mounting of the large radio telescope now under construction at the National Radio Astronomy Observatory, Greenbank, West Virginia. Completion is scheduled for some time in 1960. The starry heavens in a daytime scene symbolize the flexibility of radio astronomy for celestial observations.

Radio Observatories of the World

GEORGE S. MUMFORD, III
Tufts University

FROM as far south as Sydney, Australia, almost to the Arctic Circle, at College, Alaska, more than 60 radio observatories in 20 countries were in operation at the end of 1957. Of these, a third were in the United States, six in Germany, five in Japan, and six in the U. S. S. R. There were two observing stations in Africa, but none in the entire continent of South America.

Not included in these figures, derived from a list of radio observatories compiled for the International Astronomical Union by J. L. Pawsey, are the installations at which the primary interest is in the ionosphere and geophysics rather than astronomy, and some places where studies of moon echos, whistlers, and meteors are made.

The best-known radio observatory in the Southern Hemisphere is at the Radiophysics Laboratory in Sydney, a division of the Australian Central Scientific and Industrial Research Organization. There Dr. Pawsey and his coworkers have erected Mills crosses, steerable paraboloids, radio spectrographs, and interferometers. They investigate problems as varied as galactic structure, discrete sources, the background continuum of cosmic noise, and the polarization, positions, and angular sizes of solar bursts.

Australia is planning to build the world's second largest steerable paraboloid, an antenna 210 feet in diameter, only 40 feet smaller than the currently operating 250-foot dish at the Jodrell Bank Experimental Station, near Manchester, England. In March, Dr. E. G. Bowen, chief of the Radiophysics Laboratory, visited California Institute of Technology to discuss design plans for the new instrument. He conferred with Dr. John G. Bolton, a former Australian radio astronomer, who is in charge of the twin 90-foot dishes of the Caltech radio observatory in the Owens Valley (see front cover). Bruce Rule, chief engineer at Caltech, will accompany Dr. Bowen on a trip to England to assist with the design problems of the 210-foot instrument.

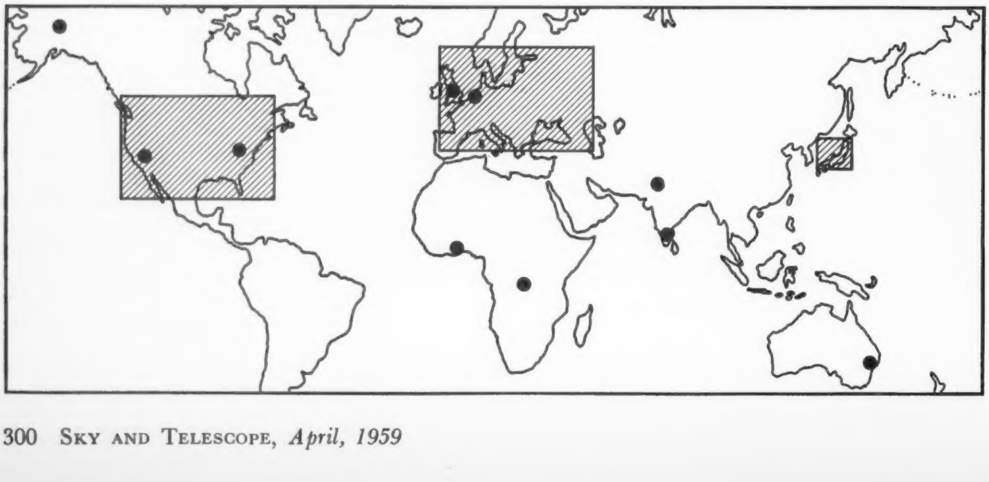
The active observatories in Africa are at Lwiro, Belgian Congo, and Achimota, Ghana. A solar patrol with a 20-foot equatorially mounted paraboloid is maintained at the former, while phase-switching interferometers and a radiometer are employed at the University College of Ghana for studies of scintillation, ionospheric absorption, and transequatorial scattering.

At the majority of radio observatories in Asia, solar observations are made. Such work is of primary importance at the Kodaikanal Astrophysical Observatory and the National Physical Laboratory, New Delhi, India. All five of the stations in Japan employ radiometers for solar work; they are located at Hiraiso, Mt. Ikoma, Nagoya, and two in Tokyo.

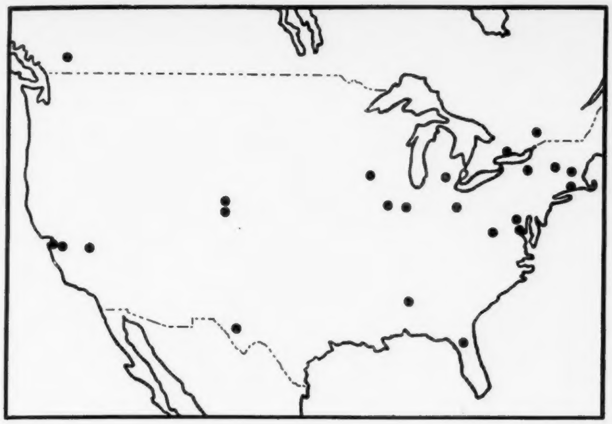
In the Soviet Union, the installations of the Crimean Astrophysical Observatory, the Research Institute of Radiophysics in Gorki, the Lebedev Physical Institute of Moscow, the Poulkovo Observatory, and the Research Institute of Earth Magnetism, all observe solar radio emission, although many investigations of discrete sources are being carried out. The primary work of the Burakan Astrophysical Observatory is in this latter field, and similar work is being carried on at Gorki, Poulkovo, and the Lebedev Institute.

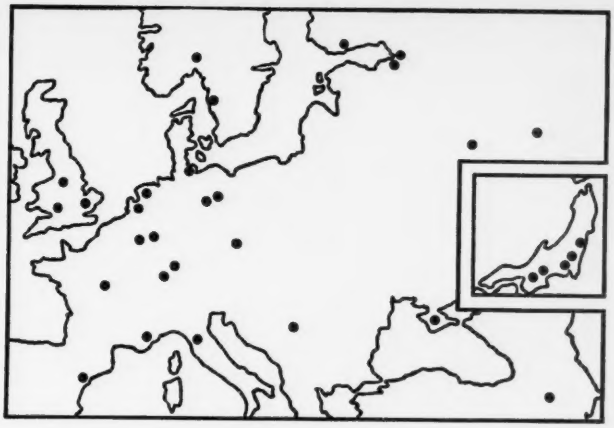
The Russian equipment is quite varied. The Crimean station of the Lebedev Institute has two radio telescopes with antennas 26 by 60 feet, a multichannel spectrograph, a polarimeter, and a 100-foot fixed paraboloid with surface accuracy adequate for reception at a wave length of three centimeters.

There are twin 25-foot paraboloids at Ondrejov, Czechoslovakia (see page 257,



The distribution of the radio observatories of the world, based on J. L. Pawsey's IAU report. For the United States only the Greenbank and Owens Valley sites are marked, while in Europe Jodrell Bank and Dwingeloo are indicated. Stations in the shaded areas are shown in larger-scale maps on the next page.





These enlargements of the shaded parts of the world map on the facing page show the principal radio observatories in the United States and Canada (left) and in Europe (right). The inset indicates five Japanese stations.

March issue), and single instruments at Belgrade, Yugoslavia; Arcetri, Italy; and Tortosa, Spain. More elaborate equipment of the Royal Observatory is operated at Humain-Rochefort, Belgium; and work is done at Helsinki, Finland, and in Norway at the Institute of Theoretical Astrophysics. At Gothenburg, Sweden, the Chalmers University of Technology has five radio telescopes, including three 25-foot paraboloids, for observing the 21-cm. hydrogen line, meteors, the sun, and aurora-induced scintillation of radio stars.

At least six radio observatories in Germany are active. At Berlin-Aldershof the sun, atmospheric extinction and refraction, and galactic radiation at decimeter wave lengths are being studied with various paraboloids, including one 120 feet in diameter, which is movable in declination. There is an 82-foot altazimuth antenna at Bonn, while smaller dishes at Freiburg, Kiel, and Potsdam are used for solar-burst studies. Solar work is also carried on at the University of Tübingen.

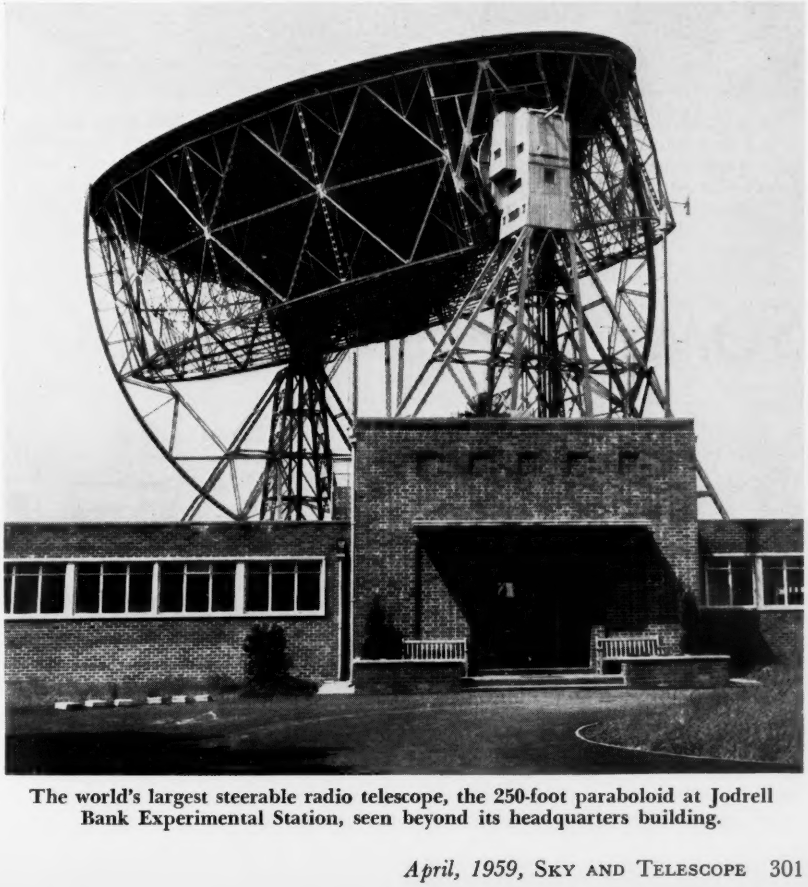
The major radio installation in France is the Nancay station of the Paris Observatory, its chief instrument being a 32-element Christiansen interferometer. Here also is a variable-spacing-and-orientation interferometer with two 27-foot paraboloids, and smaller instruments. The sun can be observed at wave lengths of three, 30, and 100 centimeters, and the galaxy at 21, 33, and 180 centimeters. The Institute of Astrophysics has a smaller station at St. Michel, near Lyons, where discrete sources are observed with an interferometer consisting of two parabolic cylinders.

Astronomers in the Netherlands have long been pioneers in radio astronomy. At Dwingeloo, several institutions, including the Leiden, Utrecht, and Groningen observatories, operate an 82-foot altazimuth and two equatorially mounted 25-foot paraboloids. Besides the well-known 21-cm. studies of galactic and extragalactic sources, much emphasis is placed on the cosmic continuum at wave lengths from 10 to 100 centimeters. Solar-terrestrial relationships is the foremost field at another Dutch observatory, at Nederhorst den Berg.

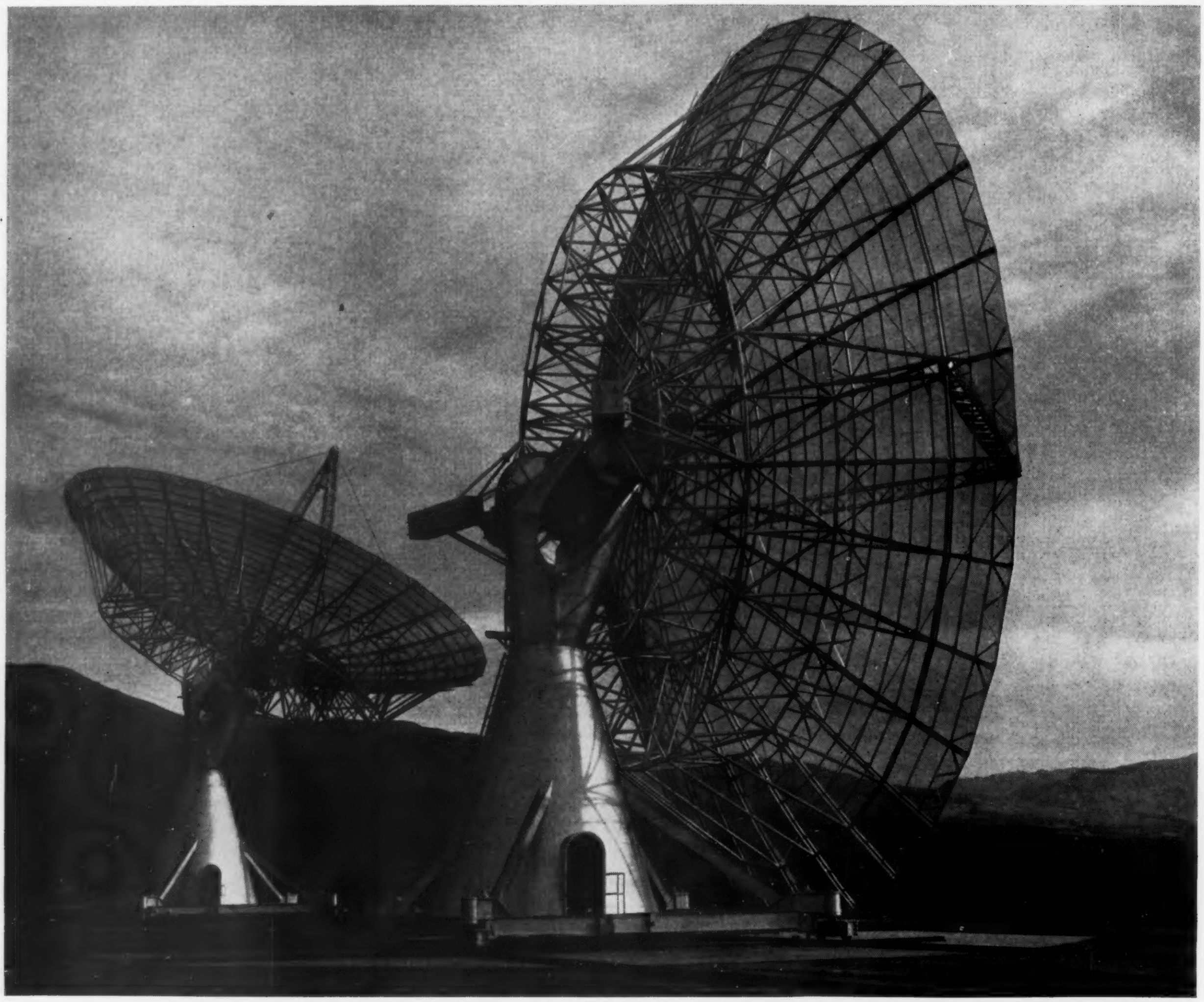
Radio work in England is done principally at three stations, the most elaborate setup being at Mullard Radio Astronomy Observatory in Cambridge, where the sun, discrete sources, galactic structure, and scintillation are among the chief fields of interest. At Jodrell Bank, the 250-foot instrument has been employed for tracking artificial satellites and space probes, for work on meteors, auroras, the moon, and galactic and extragalactic sources of radio energy. A 46-foot paraboloid is used at the Royal Radar Establishment in Malvern to study discrete sources and for moon echos.

In Canada, there is a station operated by the National Research Council near Ottawa, for solar and meteor observations. The David Dunlap Observatory operates an equatorial array at Richmond Hill, while 21-cm. studies of interstellar clouds are planned for the 82-foot equatorial paraboloid under construction at the White Lake station (near Penticton, British Columbia) of the Dominion Observatory.

Some recent American radio telescopes are pictured on the following pages.



The world's largest steerable radio telescope, the 250-foot paraboloid at Jodrell Bank Experimental Station, seen beyond its headquarters building.



The giant telescopes of Caltech's radio observatory are viewed here from the northwest, and in the front-cover picture they are seen from the southwest, against the nearest part of the White Mountains. Each 90-foot paraboloid is equatorially mounted; the nearer one is shown directed toward the southern horizon, while the farther is aimed somewhat above the celestial equator. At the bottom of the picture can be seen the wheeled supports that carry each telescope along the tracks. Although the huge dishes are built to withstand winds of 80 miles per hour, they will not be used for exacting work when gusts exceed 25 miles per hour. California Institute of Technology photograph.

SOME RADIO TELESCOPES – I

OWENS VALLEY, CALIFORNIA

"THE PROJECT is one of several designed to elevate radio astronomy work in this country to that being done in Australia, Britain, and the Netherlands. America has lagged after pioneering the new science."

With these words a scientist at California Institute of Technology indicates the importance of one of the most powerful radio telescope installations in the world, now going into operation in the Owens Valley about 250 miles north of Pasadena. Its main equipment consists of the twin 90-foot paraboloids pictured above, each equatorially mounted and movable on tracks to form part of a huge interferometer (SKY AND TELESCOPE, May, 1957, page 311).

The observatory was dedicated last December 19th, when virtually all mechanical construction was completed. Director John G. Bolton pointed out that a major part of the observing program will attempt to identify many of the 1,500 or more discrete radio sources as yet not correlated with visible celestial objects. For this purpose the twin antennas combine the pinpoint accuracy of an interferometer arrangement with large energy-gathering power and ability to be aimed anywhere in the sky.

Each dish and its more than 6,000 square feet of $\frac{3}{8}$-inch steel mesh weighs over 40 tons and is mounted on a pedestal that is 45 feet high. To assure sharp reception of radiation, each antenna must be as perfectly paraboloidal as possible. The desired shape can be attained by adjusting the reflecting skin on its tubular steel frame (tubes four inches in diameter) at 324 different points, making it feasible to eliminate flexure.

It was necessary to weld the tubes in a special sequence, teams of welders on opposing sides of a dish working outward in unison so as not to lock welding stresses into the framework. There are some 1,300 feet of welding on more than 1,000 places on each antenna.

The wheeled mountings carry the telescopes on railroad tracks 35 feet wide and 1,600 feet long. Only the east-west track is built at present, with both telescopes set on it, but one will be shifted to the north-south track when that is completed. As the antennas must be anchored against the wind while observing, stations had to be set up along the track, allowing interferometer separations of 200, 400, 800, and 1,600 feet. Each station is a group of four caissons, to which the pedestal framework can be locked with a hydraulic jack. A truck or tractor will tow the heavy instruments into position.

The giant antennas will be used for radio wave lengths from five centimeters to one meter. A 32-foot dish, built to test design features incorporated into the large paraboloids, will operate at from one to five centimeters. Dr. Bolton's research staff includes Gordon Stanley, J. A. Roberts, T. A. Matthews, and K. C. Westfold.

The cost of the installation was 1½ million dollars, of which 1.3 million was supplied by the Office of Naval Research, the remainder by business organizations. The large antennas were designed by Bruce Rule, assisted by C. W. Jones Engineering, while the Allison Steel Co., of Phoenix, Arizona, was the prime contractor.

While the equipment at the Owens Valley Radio Observatory could be used for tracking artificial satellites and space probes, it is unlikely that it will be, as Caltech's Jet Propulsion Laboratory has erected an 85-foot parabolic antenna at the Goldstone Tracking Station on the desert at Camp Irwin, California. This telescope was utilized to pick up radio signals emitted by Pioneer IV, the space probe launched on March 3rd (see page 320). By 1960, as the efficiency of the receiver is increased and as the power and size of radio transmitters in space vehicles grow, the Goldstone antenna should be able to hear signals from 40 million miles away.

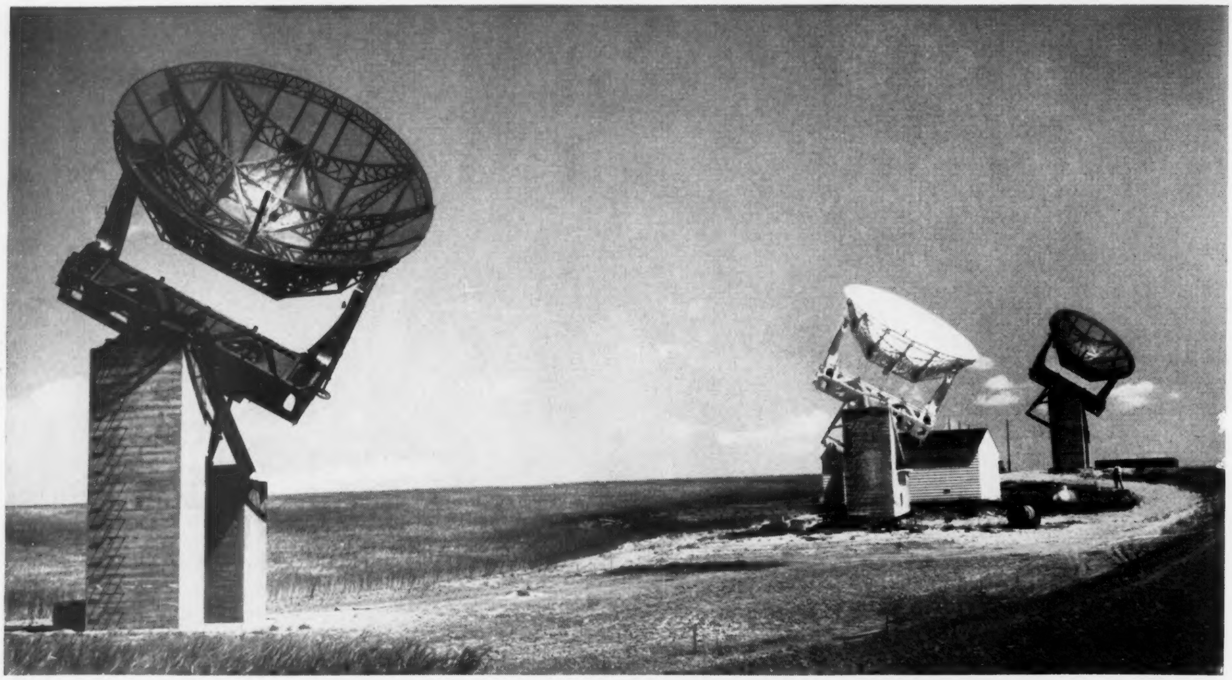
A closeup of the declination-axle (horizontal) and polar-axle assembly of a 90-foot antenna. The declination driving gears (dark-edged disks) are 11½ feet in diameter, weigh over 9,000 pounds each, and have a gear-tooth accuracy of 0.005 inch. The polar axle (center) has four 32-inch-diameter roller bearings, each weighing 800 pounds. A photographer is standing on the declination axle.

PALO ALTO, CALIFORNIA

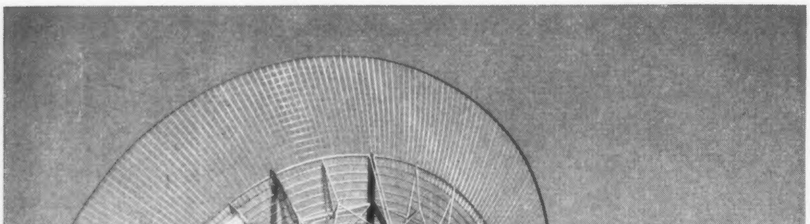
FOR ABOUT 3½ years, R. N. Bracewell and his associates at Stanford University have been working on a high-resolution interferometer designed chiefly for mapping the sun's radiation at radio wave lengths. Their device consists of 16 aluminum 10-foot parabolic mirrors set in a row 375 feet long and bisected at right angles by another row of 16. The resolving power of this giant interferometer array is equal to that of a paraboloid 375 feet in diameter. The energy gathering power, of course, corresponds only to the surface area of the paraboloids.

The beam-width of the interferometer pattern is 1/15 degree in both directions,

Left to right: Radio astronomers C. C. Lee, K. S. Yang, R. N. Bracewell, and D. A. Cuddaback (the last from University of California) gather in front of the interferometer array at the Stanford Radio Propagation Laboratory. A horn antenna attached to the gooseneck wave guide in the center of each 10-foot dish is tuned to the 10-centimeter radiation that originates in the sun's chromosphere. The paraboloids are synchronized to move in unison, scanning the sun to complete a radio map of its entire disk in about 30 minutes, even in cloudy weather. Stanford University photo.



These Wurzburg radio telescope units on Gunbarrel Hill, Colorado, are automatically controlled to point correctly, calibrate themselves, and shut off at sundown. Setting of the programming controls and servicing the equipment can be done about twice a week, so the project staff works a normal five-day week while the observations cover all daylight hours in a full week.



The 40-foot radio telescopes on Table Mesa, close to Gunbarrel Hill, are seen pointing northeastward. They are connected for synchronous operation to form an interferometer. The oil-drum counterweights are seen at the ends of the declination axle. The pictures on this page are from the National Bureau of Standards at Boulder, Colorado.

so distinct areas of only 0.003 square degree can be observed on the sun. The antennas can be moved in unison to scan the sun and thus build up a high-resolution picture of its activity at very short wave lengths. Other work on stellar and galactic radiations is also planned.

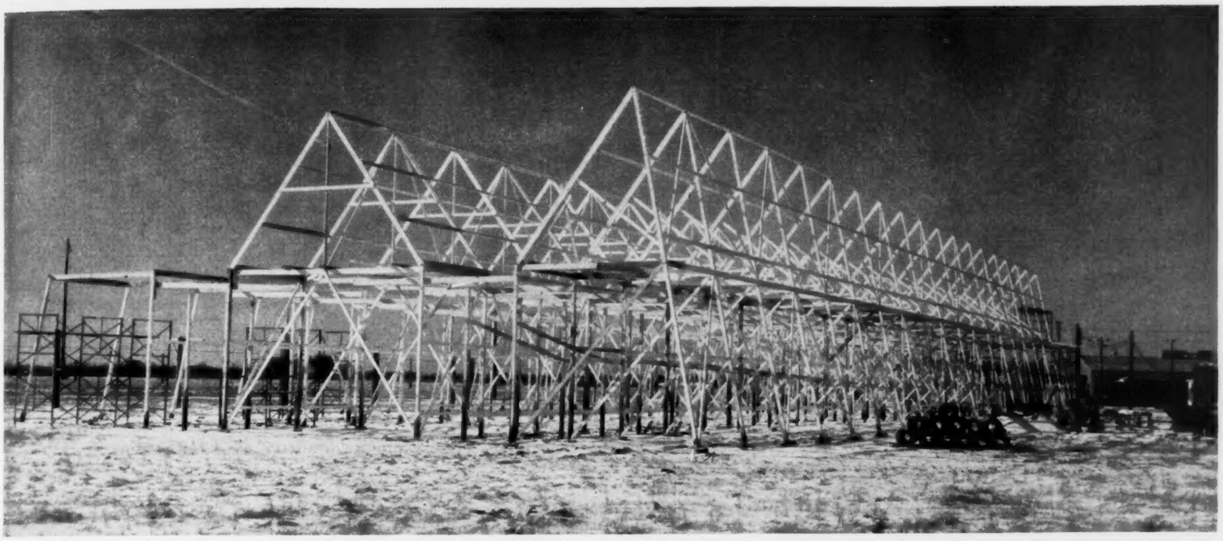
The project is being financed by grants from the Air Force Office of Scientific Research, and its total cost will be about $400,000.

BOULDER, COLORADO

AFTER the close of World War II, the National Bureau of Standards acquired three German Wurzburg radar units with 26-foot antennas. These instruments were modified for radio astronomy by the addition of new receiving equipment, equatorial mountings, and driving gears suitable for tracking the sun.

They were installed on Gunbarrel Hill, near the Boulder laboratories of the Bureau of Standards, where they form the interferometer-type system pictured above, following the sun in synchronism. Solar radio emission levels at 460 and 167 megacycles are continuously recorded on paper tapes.

On nearby Table Mesa, two 40-foot radio telescopes are in operation for scintillation studies, observations of discrete radio sources, solar work, research on the ionosphere, and to record Jupiter's radio outbursts. New 60-foot telescopes are under development, and will be on view this August when delegates to the Nationwide Amateur Astronomers Convention participate in a field trip to the Boulder laboratories (see page 324).



One of the six antennas used for radar observations of meteors at Havana, Illinois. It is 35 feet high, forming a seven-meter double-trough wave guide with an aperture 200 feet long and 70 feet wide. Harvard Observatory photograph.

HAVANA, ILLINOIS

NEAR the Illinois River southwest of Peoria, the Long Branch field station of the National Bureau of Standards is equipped for studies of meteors by radar techniques. The antennas were built by the Radiation Engineering Laboratory, Maynard, Massachusetts, and the electronic equipment by Harvard Observatory astronomers, who conduct the research under F. L. Whipple and G. S. Hawkins.

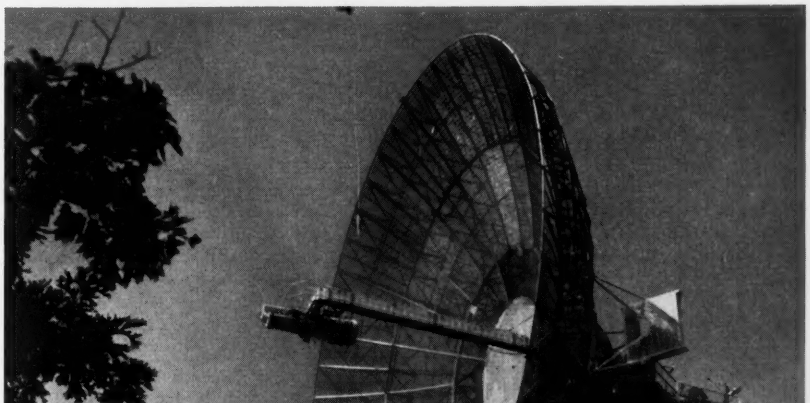
When completed, the Harvard radio meteor project will employ six antennas in all, five to be spaced on a straight line 35 miles long, with the sixth of the series offset. One of the antennas is pictured above. Radio signals sent out from the central antenna will strike and be reflected from ionized columns in the air, produced by the passage of meteors through the atmosphere. From the time differences at which the reflected energy is received at the antennas, the paths of meteors and hence their radiants and orbits can be determined. At present three of the antennas are in operation, set in a triangle.

These observations extend those being undertaken with the same type of equipment at Jodrell Bank Experimental Station in England.

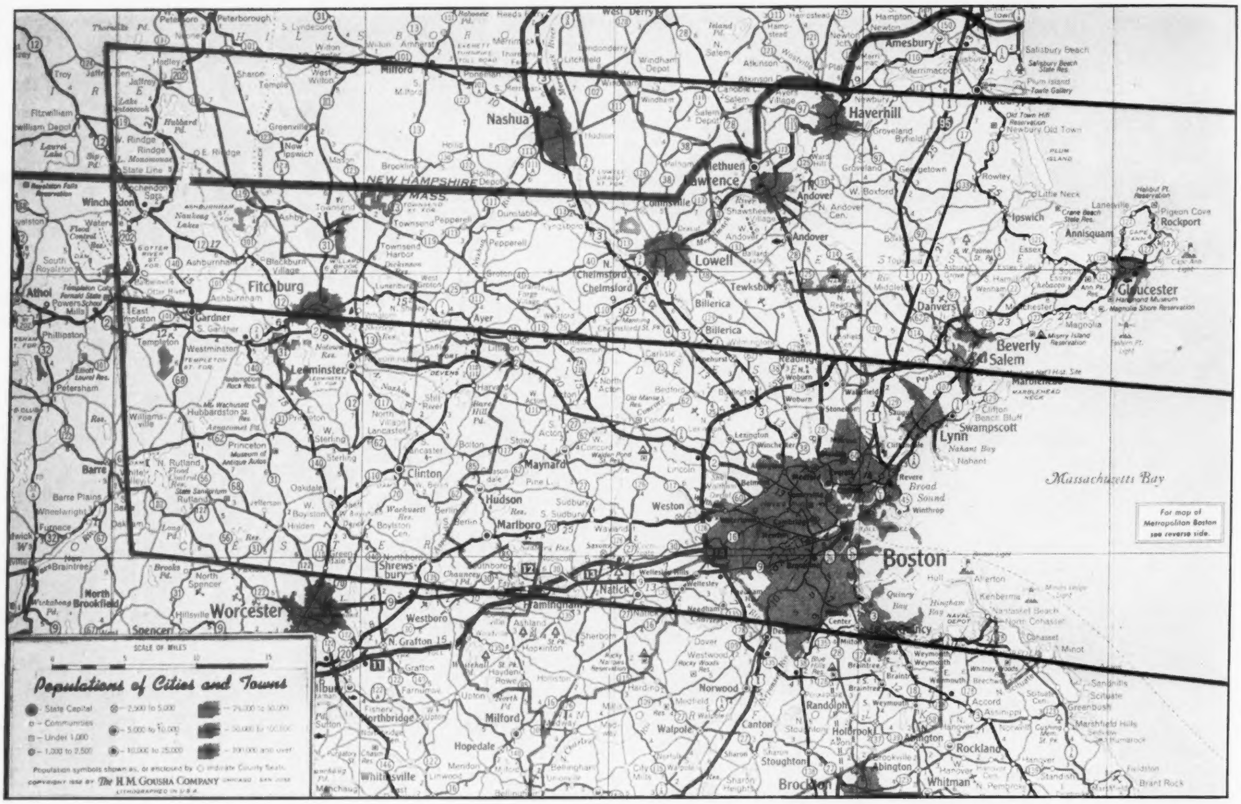
WESTFORD, MASSACHUSETTS

MILLSTONE HILL radar site is situated near Westford, Massachusetts, about 40 miles northwest of Boston near the New Hampshire state line. The installation was built and is operated by Lincoln Laboratory of Massachusetts Institute of Technology, under an Air Force contract.

Although this giant antenna is designed for defense purposes, it is also employed to track artificial satellites and rockets sent toward the moon and into solar system orbits.



A highly effective instrument for tracking artificial satellites and planets is this radar antenna at Millstone Hill, Massachusetts. It is 84 feet in diameter and weighs 90 tons. The tower on which it is mounted is 90 feet high. Official U. S. Air Force photograph.



From data prepared by the U. S. Nautical Almanac Office, the path of totality of the coming October 2nd eclipse is plotted on this road map of Boston and eastern Massachusetts. Mid-eclipse at sunrise occurs along the vertical line at the left. The central line passes north of metropolitan Boston, but is easily accessible by road. This copyrighted map and the one opposite are reproduced by permission of H. M. Gousha Co.

OBSERVING SITES FOR OCTOBER'S ECLIPSE

ROBERT E. COX, *Amateur Telescope Makers of Boston*

ALTHOUGH far more favorable observing conditions for the total eclipse of the sun this October 2nd will occur in the Canary Islands and in Africa (page 200, February issue), some American astronomers and many amateurs will want to view the spectacle from New England. Parts of eastern Massachusetts and southern New Hampshire are the only places in North America where totality will be visible, very low in the eastern sky near sunrise.

Except for Mt. Wachusett, which is south of Fitchburg, Massachusetts, and well within the path of totality, there are few eminences inland from which an observer can see a true horizon. The most suitable locations seem to be along the coast, where a direct sea horizon is obtainable and the sun's altitude will be greatest. Much of the coastline is hilly and good observing sites should not be difficult to find. In this region, however, care should be taken that the view across the water is not obstructed by islands or adjoining necks of land.

For these reasons, SKY AND TELESCOPE and the Amateur Telescope Makers of Boston have conducted site surveys and chosen two main observing places for interested amateur astronomers who will be coming from other parts of the country to view the eclipse. The SKY AND TELESCOPE party will be located on the grounds of the United States Coast Guard Air Rescue Station at Winter Island, east of Salem, while the ATM party will be along the Nahant Beach Parkway, southeast of Lynn.

From both of these sites the solar disk will be completely covered by the moon for about 55 seconds, with the lower edge of the sun one degree above the horizon when totality begins at 6:50 a.m. Eastern daylight time. The partial eclipse will come to an end one hour later.

The ATM party, which is being organized as part of the program for the Northeast Region convention of the Astronomical League, is only a short distance south of the central line. There are unlimited parking facilities along a mile or more of ocean front, yet the latter does not suffer from traffic interference.

The SKY AND TELESCOPE site is nearer to the central line, but admittance to the Coast Guard station will be limited to those who have registered in advance with this magazine. Reservations should be sent not later than September 1st. Shortly after that date, entry cards and road maps will be forwarded to registrants.

The actual observing location at the station is on the ruins of Ft. Pickering, affording an unobstructed view to the east across Salem Harbor. The tip of Marblehead, known as Naugus Head, is to the right, south of the sun, with a number of small islands on the distant horizon.

This fort had its beginning in 1643, and was named Ft. William in 1699 for the king of England. After the Revolutionary War, it was renamed Ft. Pickering, for Timothy Pickering, the secretary of state and of war under President Washington. The fort was rebuilt and kept in fighting condition, being garrisoned by troops in the War of 1812. The last reconstruction was in 1863 during the period of threatened conflict with Great Britain. It has, however, never been under any actual hostile attack.

Access to the air station is via the his-

torical city of Salem and roads leading to Winter Island, as may be seen in the accompanying map. The host, Cmdr. J. A. Cornish, has kindly approved admitting observers from 4 a.m. onward, in sufficient time for setting up portable instruments and orienting them to the rising sun. Observers may transport their equipment by automobile close to the site, then park in designated areas. It is expected to have a 110-volt 60-cycle electric power source for the operation of tracking telescopes and cameras. The party will leave at 8 a.m., after viewing the closing phases of the eclipse.

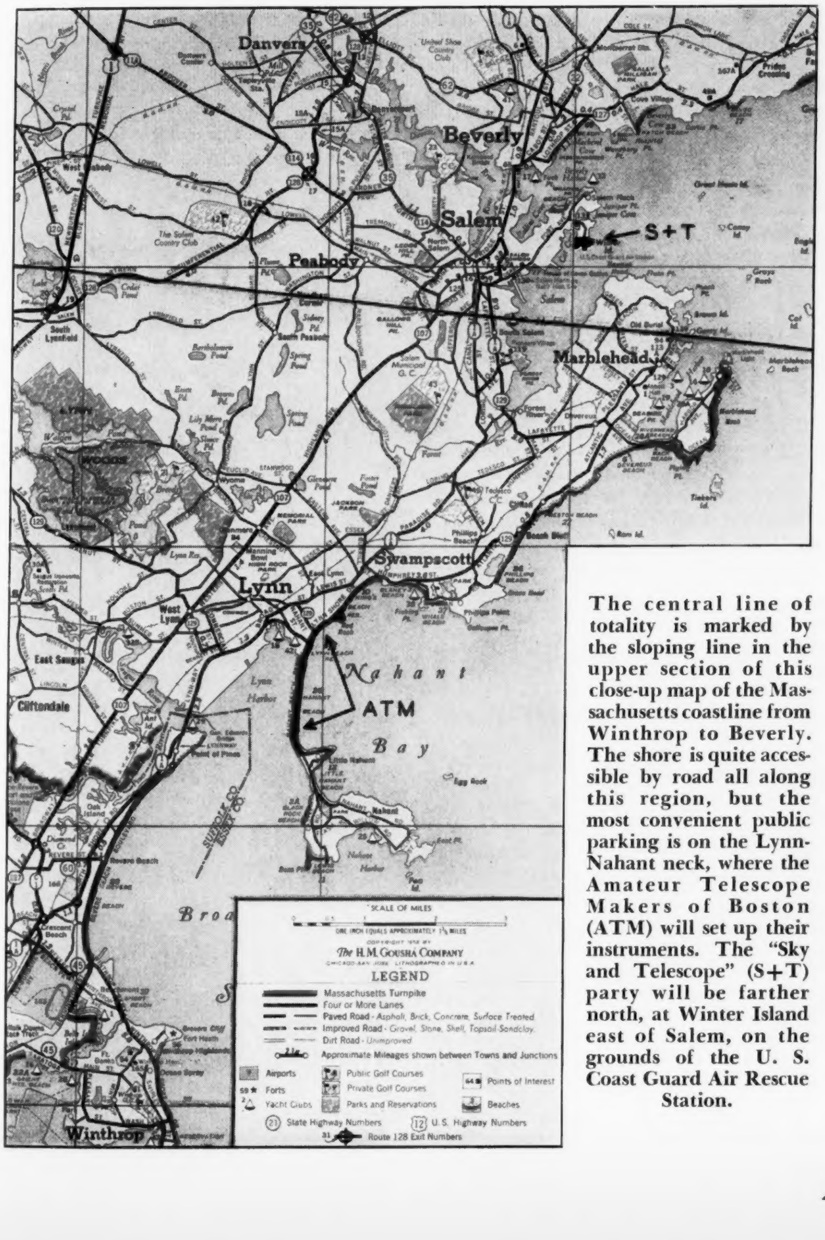
Sky and Telescope will assume no responsibility for the suitability of this site for observers who may have special problems, but it is believed to be an excellent location for general programs. Weather conditions early in October should be favorable, although there is a possibility of fog or haze over the ocean horizon so early in the morning. The Ft. Pickering site is some 20 feet above sea level, but the higher locations in the vicinity are either private or suffer from other disadvantages for a large observing party.

Overnight accommodations in Salem and Lynn, as well as Boston and its environs, are plentiful. Excellent highways lead from central Boston to all points on the North Shore where eclipse observing sites are located.

Following the eclipse, observers are invited to the Boston Museum of Science for coffee and doughnuts. That afternoon, at a special meeting in the Morse auditorium of the Charles Hayden Planetarium, a general roundup of eclipse observing reports is scheduled. There will be time for commercial processing of some photographs to be shown at the roundup.

The Museum of Science program will be part of the annual convention of the Northeast Region of the Astronomical League, to be held October 2-4, 1959. Sponsors are the Amateur Telescope Makers of Boston, the Boston Museum of Science, and the Bond Astronomical Club, with the American Association of Variable Star Observers, the Research Station for Satellite Observation, and Sky and Telescope co-operating.

The opening session will be held early Friday afternoon, followed by the eclipse roundup, and concluding with a planetarium demonstration. Sessions for papers are to be held Saturday morning, and a field trip to Harvard Observatory's Agassiz station that afternoon. The convention banquet is on Saturday evening. Some sessions of the AAVSO at Nahant will be held concurrently.



The central line of totality is marked by the sloping line in the upper section of this close-up map of the Massachusetts coastline from Winthrop to Beverly. The shore is quite accessible by road all along this region, but the most convenient public parking is on the Lynn-Nahant neck, where the Amateur Telescope Makers of Boston (ATM) will set up their instruments. The "Sky and Telescope" (S+T) party will be farther north, at Winter Island east of Salem, on the grounds of the U. S. Coast Guard Air Rescue Station.

LETTERS

Sir:

The remarkable report by N. A. Kozyrev (February, page 184), on visual and spectrographic observations of volcanic activity in the lunar crater Alphonsus, merits close examination. Obviously, the conclusions have a direct bearing on the processes invoked to account for the lunar craters and their central mountains.

One aspect of the report must be questioned, the nature of the emission bands mentioned in the text. Inspection of photographic copies of the spectrum fails to show any band structure superposed on the Fraunhofer spectrum of the central peak; only a continuous emission patch appears to overlay the Fraunhofer spectrum near 4700 angstroms. The rest of the peak spectrum has, in relation to the walls and floor, very nearly the intensity to be expected for a well-guided spectrum, as was found by comparison with a number of spectra taken at the McDonald Observatory, and as follows also from the intensity of the peak on direct photographs, which for all phases is considerably greater than that of the crater floor. An appreciable difference exists between the two published spectra regarding their intensity distribution with wave length; but this difference does not seem to be present in other copies that have been in circulation among astronomers.

The article attributes the 4700-angstrom emission to the Swan band of the diatomic carbon molecule C_2, which has its band-head at 4737, a value in close agreement with the spectrum reproduced. It should be pointed out, however, that against the sunlit moon the 4737 Swan band of C_2 would have been observed not in emission, but in absorption; while the associated band at 5129 angstroms should have been present weakly in emission. This follows from the classification of the relevant vibrational states and the known transition probabilities. It seems evident that C_2 has not been observed (nor would it be expected on the basis of terrestrial experience) and that the nature of the 4700 feature is not explained.

GERARD P. KUIPER
Yerkes Observatory
Williams Bay, Wis.

NEWS NOTES

PECULIAR NEW STAR

The detection of a faint blue star in Aquarius, reported in Harvard *Announcement Card* 1427, has raised a puzzling question of interpretation. The discovery was made by W. J. Luyten, University of Minnesota, and G. Haro, of Tonanzintla Observatory in Mexico, while they were guest investigators at Palomar Observatory.

On examining a 48-inch Schmidt photograph taken November 5, 1958, they noted a 17.5-magnitude star, which was invisible, and hence fainter than photographic magnitude 22.0, on a Sky Survey plate taken with the same telescope in 1954. There could be no doubt of the reality of the star on the November photograph, as this bore three exposures, in ultraviolet, blue, and yellow light. The three images had relative intensities similar to those of a white dwarf star. No other record of it is known to exist.

Practically all novae appear in or close to the Milky Way, but the Luyten-Haro star has a galactic latitude of $-71°$. Hence it can scarcely have been a common nova. Possibly it was a distant nova that flashed up in the tenuous corona of stars surrounding the flat main body of our galaxy; the nova T Bootis in 1860 seems to have been such a star. The new object can scarcely have been a flare star, for the three exposures, totalling 63 minutes, show it substantially unchanged in brightness. Dr. Luyten mentions the conjecture that the object may be a previously unobserved type of dwarf nova, which collapsed catastrophically into a neutron star, a process predicted by F. Zwicky.

COMET 1959a

The first comet discovered in 1959 was a 16th-magnitude object in Aries. It was detected on January 27th by Charles Slaughter while he was examining a photograph he and Robert Burnham, Jr., had taken seven weeks earlier with the Lowell Observatory 13-inch refractor, as part of a search for stars having large proper motions.

Nine of their plates, taken between December 10 and 15, 1958, showed Comet Slaughter-Burnham, its image diffuse with a central condensation. From positions measured on these plates, preliminary orbital elements and an ephemeris of predicted positions were computed by Elizabeth Roemer at the Flagstaff station of the U. S. Naval Observatory.

According to Dr. Roemer's calculations, Comet 1959a is moving in a markedly elliptical orbit (eccentricity 0.52) with a period of about 11 years. When the comet passed through perihelion last August 4th, it was 2.4 astronomical units distant from the sun. In the fall months it was very favorably placed on the sky, and examination of observatory photographs taken then might reveal some prediscovery images.

Meanwhile, attempts to photograph the comet with the 13-inch Lowell telescope were unsuccessful after January 27th. But on the basis of Dr. Roemer's ephemeris, it was reobserved with the Naval Observatory's 40-inch reflector on February 2nd. It was then of the 18th magnitude, with a nearly stellar central condensation and a trace of a coma. As it continues to recede from both the earth and the sun, the comet may soon become unobservable even in very large telescopes.

LICK OBSERVATORY PLANS NEW SKY ATLAS

If the demand warrants, Lick Observatory will prepare a photographic sky atlas showing stars to approximate magnitude 16. Costing about $125 to $150, the edition will be printed when as many as 10 orders are received. The unbound set will contain 166 negative reproductions, about 11 by 12 inches in size, on double-weight paper.

The atlas will be made from plates taken at Lick for C. D. Shane's census of 15th-magnitude galaxies, a program that required a homogeneous survey. The instrument was a 10-inch telescope borrowed from Mount Wilson Observatory, fitted with the same Ross 5-inch f/7 lens that was used for the famous Ross-Calvert *Atlas of the Milky Way*. The exposures were made on Kodak 103a-O plates for 90 minutes. The reproduced portion of each plate is 18.8 degrees east-west by 17.8 degrees north-south, with a scale of about 3.88 minutes of arc per millimeter.

The plates are centered on parallels of declination 15 degrees apart, starting in the south at $-30°$. In right ascension the spacing is one hour for declinations $-30°$ to $+30°$. For more northern declinations, it is as follows: $+45°$, one hour 12 minutes; $+60°$, one hour 36 minutes; $+75°$, two hours 24 minutes; and one plate at $+90°$.

Organizations interested in obtaining the atlas should write Dr. A. E. Whitford, Director, Lick Observatory, Mt. Hamilton, Calif.

SPACE ENVIRONMENT SYMPOSIUM

A series of 13 lectures on space science is currently being presented by the department of aeronautics and astronautics at Massachusetts Institute of Technology. The symposium began in February and will continue through May. All lectures are open to the public and begin at 3 p.m. in the Kresge Auditorium in Cambridge, Massachusetts.

The talks for April and May are: April 6, "Cosmic Rays," Dr. Robert B. Leighton, California Institute of Technology; April 16, "The Moon," Clyde W. Tombaugh, New Mexico State University; April 23, "Physical Properties of the Upper Atmosphere," Dr. Richard F. K. Herzog, Geophysics Corp. of America; April 30, "Air Glow Phenomena in the Upper Atmosphere," Dr. Murray Zelikoff, Geophysics Corp. of America.

May 4, "The Geochemistry of Space and the Solar System," Dr. Harold C. Urey, University of California; May 14, "Instrumentation for Environmental Research," Dr. Herbert Friedman, Naval Research Laboratory; May 21, "Environmental Effects on Vehicle Designs," Dr. H. Guyford Stever, M.I.T.

JOHN JACKSON DIES

A British astronomer who was a specialist in measuring star distances died on December 12, 1958, at the age of 71. John Jackson had served as director of the Royal Cape Observatory, South Africa, from 1933 to 1950. For 20 years before that, he was the chief assistant at Greenwich Observatory.

Dr. Jackson's interests lay mainly in positional astronomy — the determination of the positions, proper motions, and trigonometric parallaxes of stars. Also an authority on visual double stars, he pioneered in the evaluation of dynamical parallaxes for binaries that had been observed over only a small part of their orbits.

The Royal Astronomical Society awarded Dr. Jackson its gold medal in 1952, and he served as its president from 1953 to 1955. In addition to his professional work, Dr. Jackson was active in supporting amateur astronomy. He was president of the Astronomical Society of Southern Africa for two terms.

IN THE CURRENT JOURNALS

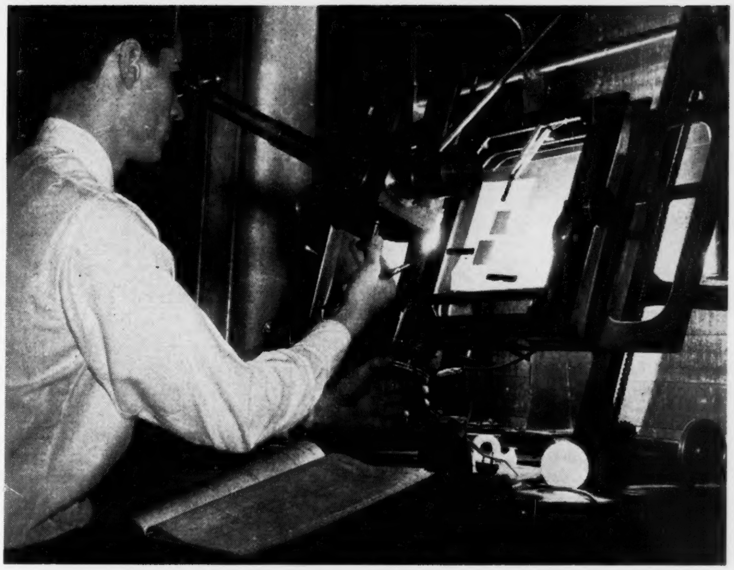
THE MEANOOK-NEWBROOK METEOR OBSERVATORIES, by Peter M. Millman, *Journal* of the Royal Astronomical Society of Canada, February, 1959. "The full-scale programme of observation cannot be considered to have commenced until 1954. By the end of 1957 some 1800 pairs of exposures had been made with the two Super-Schmidt cameras, the normal exposure being 12 minutes in length. . . . During this time some 600 meteor photographs were secured (including 165 paired photographs), an overall rate of one meteor photograph for every 60 to 70 minutes of exposure time."

MICROFILMS AVAILABLE

Observatories, libraries, and individuals wishing to obtain microfilm editions of SKY AND TELESCOPE for volumes IX through XVII may procure them from University Microfilms, 313 N. First St., Ann Arbor, Mich. The price for volumes IX, X, and XI is $1.50 apiece; for volumes XII, XIII, and XIV, $1.60; volumes XV and XVI, $2.05; volume XVII, $2.30. Orders should be placed directly with University Microfilms.

VARIABLE STARS

OTTO STRUVE
Leuschner Observatory
University of California



An astronomer uses a blink comparator to discover variable stars. Flipping a knob brings alternately into view two photographs of the same sky region, taken at different times. Harvard Observatory photograph.

AN IMPORTANT recent event in astronomy was the publication last year of the second edition of the *General Catalogue of Variable Stars,* by the Moscow astronomers B. V. Kukarkin, P. P. Parenago, Y. I. Efremov, and P. N. Kholopov. This listing of 14,708 variables includes a vast amount of new information about many of the 10,912 stars in the first edition, published 10 years earlier. The catalogue has grown from a single book of 528 pages to a 1,176-page two-volume work.

The accompanying table illustrates the progress made during the intervening decade in the study of different types of variables. Three objects, the semiregular variable Eta Geminorum, the nova DQ Herculis, and the novalike variable AR Pavonis, have been entered twice in the totals for 1958, as they are also eclipsing binaries.

The largest percentage increase for types recognized in 1948 is for the RW Aurigae variables. These rapidly and erratically changing stars are often associated with nebulosity. Their discovery has resulted from special efforts by several observers who have carefully searched dark and bright nebulae, finding near them many variables whose spectra show the hydrogen-alpha line in emission. The authors of the catalogue also call attention to the great increase in the number of variable stars whose spectra have been classified: 2,330 or 21.4 per cent in 1948, and 4,013 or 27.3 per cent in 1958.

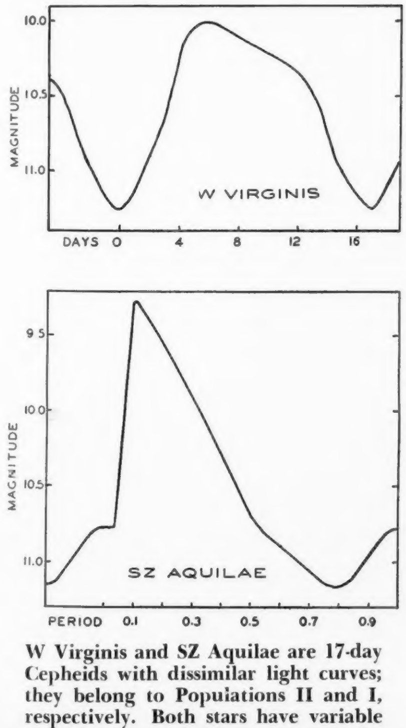
On the other hand, they point out that the number of variables observed insufficiently to be assigned to a type is still too large. Fortunately, however, the recently discovered variables have been more thoroughly studied, so the stars whose type of light curve is unknown have fallen from 9.7 to 6.7 per cent of the entire list. But there are still many variables about which little is known except that they change in brightness.

The great majority of the 14,708 objects in the catalogue have been discovered by photographic means, through intercomparison of plates taken of the same region of the sky on different dates. These are usually stars whose brightnesses change by more than a fourth of a magnitude. Photoelectric discoveries constitute only a small fraction of the total, and hence the limited membership of certain types is deceptive.

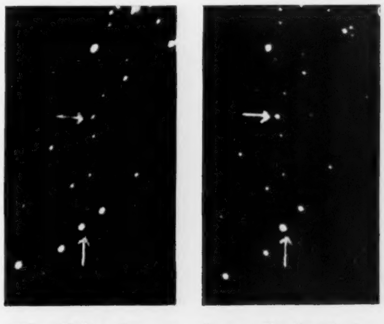
For example, only 11 stars of the Beta Canis Majoris type are listed. All are brighter than apparent magnitude 6.3, and only one (BW Vulpeculae) has a brightness range as large as 0.23 magnitude. There must be hundreds of these stars, easily observable in 10- to 15-inch telescopes, but their discovery requires photoelectric precision. The situation is similar for the Delta Scuti and Alpha^2 Canum Venaticorum variables, while the list of flare stars, such as UV Ceti, must also be very incomplete. Flare stars remain at constant brightness most of the

Type of variable	*1948*	*1958*
Classical Cepheids	497	610
Irregular	973	1,370
Omicron Ceti (Mira)	3,025	3,657
Semiregular	1,046	1,675
RR Lyrae	1,720	2,426
RV Tauri	72	92
Beta Cephei (Beta Canis Majoris)	6	11
Delta Scuti	—	5
Alpha^2 Canum Venaticorum	—	9
Novae	114	146
Novalike	25	35
Supernovae	—	7
R Coronae Borealis	35	39
RW Aurigae	173	590
U Geminorum	77	112
UV Ceti	—	15
Z Camelopardalis	15	15
Eclipsing binaries	1,913	2,763
Unusual types	11	10
Unknown types	1,060	982
Constant brightness*	150	142
	10,912	14,711

*Stars previously catalogued as variables but subsequently shown to be nonvariable.



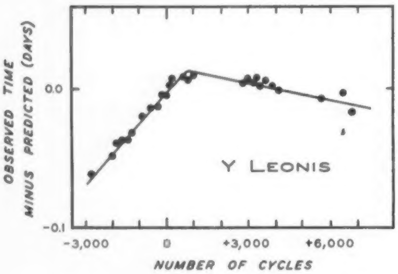
W Virginis and SZ Aquilae are 17-day Cepheids with dissimilar light curves; they belong to Populations II and I, respectively. Both stars have variable periods. Harvard Observatory graphs.



The light changes of two Cepheids in Carina are shown on Harvard patrol plates: VY (upper) has a period of 18.9 days, SX (lower), 4.86 days.

time and their outbursts last only a few minutes — these objects are usually discovered by pure chance.

In their preface, the authors of the catalogue emphasize that their work is the fruit of active co-operation by astronomers in all parts of the world. They



V. P. Zessevitch's diagram for the eclipsing star Y Leonis shows that its period shortened abruptly by 2.4 seconds about the year 1925.

acknowledge the help received from some 100 variable star investigators in 23 different countries and six Soviet republics. They write:

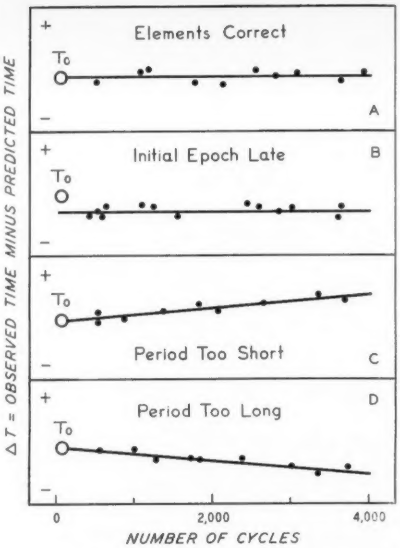
"We are quite sure that the international collaboration of astronomers in the domain of variable star studies will be strengthening and developing and will serve as a contribution in the consolidation of peace in the whole world."

Amateur astronomers may be intrigued by the nearly 1,000 variables whose type of variation is still not determined, and may wonder whether they can make useful contributions by observing the light curves of some of these unstudied objects. There is much work to do, and observations of moderate precision are usually sufficient to tell whether a variable is an eclipsing binary, a Cepheid, or one of the other types. While visual studies with a telescope of moderate size are adequate in many cases, photographic observations with lenses of 5- or 6-inch aperture can be more effective.

However, a prospective observer should bear in mind that most of the unstudied variables are quite faint, generally beyond 13th magnitude. Of the 16 untyped variables in Cygnus, for example, the four brightest are MT Cygni, magnitude range 12 to 13 photographic; CK Cygni, 12.0 to fainter than 14.5; BE Cygni, 12.5 to 13.7; and BX Cygni, 12.8 to 13.7. To identify such stars, good charts are necessary.

There are numerous other variables for which the catalogue shows the type with a question mark. Many are somewhat brighter than those mentioned above, and more accurate observations are needed to confirm or disprove the tentatively assigned type of variation.

Amateurs in many countries render great service to astronomy by systematically observing the brightnesses of long-period variables like Omicron Ceti — the famous Mira — as well as of all kinds of irregular and semiregular variables. These stars usually have large amplitude ranges, and hundreds of them are bright enough for visual work with small telescopes. As their light curves are not precisely repeated from cycle to cycle, they must be recorded continually. Those who are in-

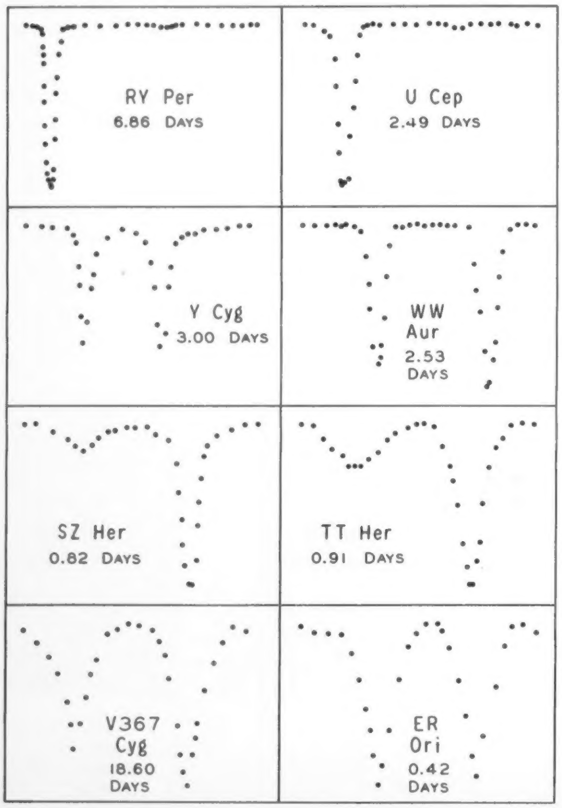


Four hypothetical cases of variables with constant periods to illustrate differences between the observed and predicted times of minima (or maxima).

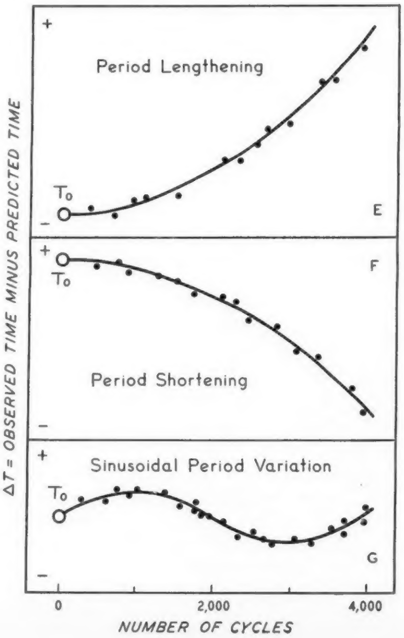
terested in this kind of work should contact the American Association of Variable Star Observers, 4 Brattle St., Cambridge 38, Mass., or some similar organization abroad.

Another branch of variable star astronomy that is growing in importance is the study of changes in the periods of light variation. Amateurs can make valuable contributions in this field. A considerable number of eclipsing and pulsating stars that have been observed for a decade or more show a lengthening or shortening of period. Probably all stars of these types, if sufficiently studied, would be found to have such changes.

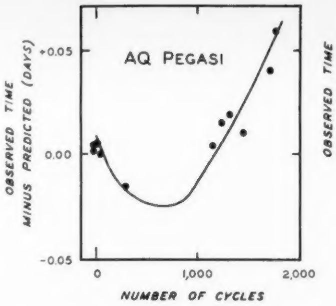
Two major articles on this subject appeared last year in the Russian journal

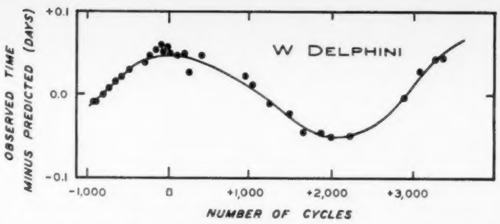


Left: These light curves for eight eclipsing variable stars were compiled by S. Gaposchkin from estimates of brightness on Harvard Observatory patrol photographs. Adapted from "Annals" of Harvard Observatory, Vol. 113.



Right: Three schematic departure diagrams show how change in the period of a variable star can be recognized. In the two upper plots, the period is increasing (E) or decreasing (F) at a uniform rate. Case G illustrates a rhythmic variation in period.





Two of Zessevitch's plots show that the period of AQ Pegasi is lengthening, while that of W Delphini seems to oscillate in a 50-year cycle.

Variable Stars. In one, Parenago discusses the period changes of Cepheids; the other, by V. P. Zessevitch, director of Odessa Observatory, concerns eclipsing binaries. All of the stars they treat are quite bright, some being within reach of binoculars. Their investigations depend on well-observed times of minimum light for the eclipsing stars, and of maximum light for the Cepheids. Photoelectric accuracy is not required; in fact, most of the minima and maxima discussed are from visual observations with small telescopes. Practical instructions for deriving the time of minimum of an Algol-type variable were given on page 190 of the February, 1957, issue of SKY AND TELESCOPE.

As an example, consider the eclipsing system Y Leonis, a star normally of magnitude 9.5. Every day and a half it fades to 12.7 and brightens again, the eclipse lasting seven hours. For this star the Moscow catalogue gives a precise time of one minimum as Julian Day 2,433,689.455, corresponding to February 11, 1951, 22:55 Universal time. Call this epoch T_0. Also given is the value of the period valid then, 1.686071 days, which we designate P_0.

To predict the times of subsequent minima of Y Leonis, we add to the initial epoch T_0 whole number multiples of the period P_0, that is,

$$T_n = T_0 + nP_0.$$

For instance, after 1,000 cycles of the star's light variation, we would expect a minimum to occur at

$$T_{1,000} = 2,433,689.455 + 1,686.071 = 2,435,375.526.$$

Suppose we find from our observations of Y Leonis on that night that minimum light occurred not at time $T_{1,000}$ but earlier or later than this by a small interval ΔT. There are three possible explanations: T_0 may be incorrect, or P_0 is incorrect, or the period itself has changed and no longer has the value P_0. We can decide among these possibilities (which may also occur in combination) if many times of minimum light have been observed over the course of several years.

Such observations of Y Leonis are available, and may be analyzed by plotting a "departure diagram" — a graph in which each ordinate is the observed time of a minimum minus its predicted value, the abscissa being the number of cycles elapsed since time T_0. Before turning to Zessevitch's diagram for Y Leonis, let us first consider some possible forms of these charts, as sketched opposite.

Naturally, there is some irregularity or "spread" in the observed points, represented by the dots. But through them we draw a smooth line or curve. If it is straight and horizontal, and passes through the point for time T_0, as in case **A** of the schematic graphs, we infer that the initial epoch T_0 and the period P_0 were correctly evaluated and that the period has not changed. Case **B** shows that T_0 was slightly incorrect, but the period is valid. In the other two cases, the original observer gave T_0 correctly, but the period was made slightly too short in **C**, and slightly too long in **D**.

In the four cases above, the straight-line curve indicates that the period itself is not changing. If it is steadily lengthening or shortening, however, the departure curve becomes a parabola, as in **E** and **F**.

Another possibility sometimes encountered is a rhythmic fluctuation in period. Case **G** shows the departure diagram for an eclipsing binary that is traveling in a circular orbit around a third star. When the variable is on the near side of its relative orbit, we observe its minima early since ΔT is then negative; the minima are late when it is on the far side.

All three types of period change have been observed among eclipsing variables. Beta Lyrae (not shown) resembles case **E**, but its 12.9-day period is increasing at a not exactly uniform rate. AQ Pegasi also has a lengthening period, but in Zessevitch's diagram the apex of the parabola is not at T_0, because the initial period was taken slightly too short. W Delphini is an example of case **G**.

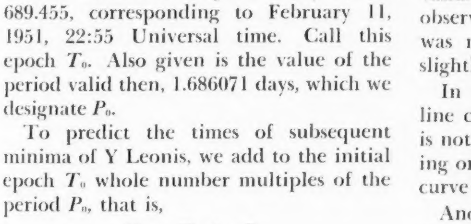
Among the most remarkable plots of ΔT against T are those having straight lines with abrupt changes of slope, which indicate sudden changes from one constant period to another. Variables with such "period jumps" are by no means rare. The graph for Y Leonis shows one abrupt change in period and many Cepheids, among them Eta Aquilae and Zeta Geminorum, have similar behavior.

Both Russian astronomers have derived some general conclusions from their studies. Zessevitch finds that among the eclipsing stars the changes in period are larger for those with longer periods. Binaries with periods shorter than one day show only small, irregular effects. For two- to four-day periods, the departures may accumulate to ± 0.1 day in the course of a few decades. Increasing and decreasing periods are about equally common.

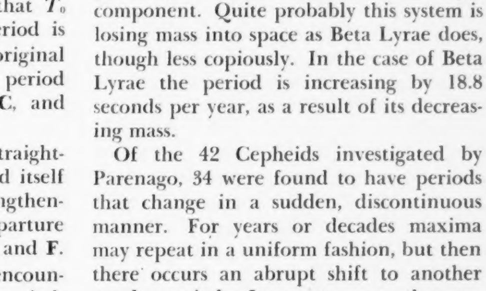
Among the stars discussed by Zessevitch, AQ Pegasi is especially interesting. The departure curve shows an increase at the rate of 0.5 second per year. This star has a peculiar spectrum, as I was able to determine in 1945. Its hotter, smaller component rotates rapidly, and is surrounded by a ring of luminous gas, which has probably streamed from the cool, larger component. Quite probably this system is losing mass into space as Beta Lyrae does, though less copiously. In the case of Beta Lyrae the period is increasing by 18.8 seconds per year, as a result of its decreasing mass.

Of the 42 Cepheids investigated by Parenago, 34 were found to have periods that change in a sudden, discontinuous manner. For years or decades maxima may repeat in a uniform fashion, but then there occurs an abrupt shift to another steady period. In most cases, the star has alternately longer-than-average and shorter-than-average periods, but occasionally the change results in a still longer or still shorter period. The curve for Eta Aquilae has been marked to indicate three discrete values of its period, which has been lengthening. Polaris is another example of this kind, its four-day period having abruptly increased by 2.3 minutes around the year 1928.

For different Cepheids, the size of the jump, ΔP, ranges from 10^{-3} to 10^{-6} (one



The period jumps of two well-known Cepheid variables are plotted here. Eta Aquilae, which has a visual range of 0.8 magnitude, has been observed for some 170 years. Polaris, with a range of only 0.1 magnitude, has been usefully studied for eight decades. Numbers along the curves are periods in days. After Parenago.



thousandth to one millionth) of the period, P. If we denote by m the average number of cycles during which the period remains constant, it turns out that the product $m\Delta P/P$ is independent of the period. This product is of the order 0.1 for Cepheids of Population I (Delta Cephei stars), and about one for Cepheids of Population II (W Virginis and RR Lyrae stars).

In the case of Eta Aquilae, the period of 7.18 days remained constant for about 3,000 cycles, then changed by 0.000148 day on the average. The product of the last two quantities divided by the first is 0.06. W Virginis, on the other hand, had a period of 17.27 days, which after about 550 cycles changed by 0.0076 day, giving for $m\Delta P/P$ the value 0.24.

It has long been known for pulsating variables that the period squared times the average density is a constant, that is, $P^2\rho$ = Constant. (This law was discussed for Beta Canis Majoris stars on page 76 of the December, 1958, issue.) The value of the constant is nearly the same for all Cepheids, indicating that those with the same periods have the same densities.

From this formula, we can deduce how much the period of an *individual* Cepheid would be altered by a change in the average radius, provided the star's other characteristics are unaffected. Percentagewise, an alteration in radius will produce $1\frac{1}{2}$ times as much alteration in period. Hence a period jump of 10^{-6} of the period could result from change in the radius of a star by one part in $1\frac{1}{2}$ million.

Parenago thinks it is rather improbable that the average radius of a Cepheid changes in such a way. Instead, he suggests that small changes in mean surface temperature (or in average absolute magnitude) may be responsible. He does not give the details of his calculations, but I suspect that he used the $P^2\rho$ formula in the following way.

The average density ρ can be replaced by a relation involving the surface temperature, the absolute magnitude, and the mass, the latter two quantities remaining unchanged. In this case, percentagewise, a temperature alteration produces three times as much deviation in the period. Thus, for a Cepheid whose temperature is 10,000°, lengthening of the period by one part in 10,000 would require a decrease of only $\frac{1}{3}$ degree in surface temperature.

It is clear that exceedingly slight changes in temperature (or absolute magnitude) of a Cepheid can produce easily observable changes in period, if the times of maximum light have been recorded for some decades. It appears that studies of period change are by far the most sensitive test available to the astronomer for detecting minute alterations in the physical characteristics of a star. Despite the delicacy of the test, the necessary observations are well within the ability of an amateur astronomer skilled in variable star work.

ASTRONOMICAL SCRAPBOOK

Some Comet Finds

ANYONE who wants to gain fame as the discoverer of half a dozen or so comets has two courses open. One way is persistent visual searching with a suitable telescope, with the willingness to spend 100 or 200 hours of sweeping for each comet. The other is to be engaged in some quite different kind of astronomical work, involving a long-term observing program with a fast, wide-field photographic telescope like the Palomar 48-inch Schmidt or the Lick 20-inch refractor. If each plate is examined promptly and thoroughly, it is possible to roll up a respectable cometary score as a byproduct.

However, many discoveries of comets have been lucky hits, involving neither of these systematic procedures. One instance was in the early 1880's, when the American astronomers Barnard, Brooks, and Swift were patrolling the skies so closely that for several years no comet was discovered by anyone else, except in the far southern sky.

At this time the Dudley Observatory at Albany, New York, had just been rebuilt and re-equipped by public subscription. A delegation of citizens was visiting the director, Lewis Boss, when someone remarked that comets were being discovered at other institutions, and that Albany should not be left behind. In a joking way, Boss turned to his assistant and said, "You see, Mr. Wells, you must discover a comet."

Wells did just that within a week! His find was 1882 I, a fine naked-eye object which remained in view for five months, and for which at least 18 sets of orbital elements were computed, in one case from 1,050 measured positions.

There are a number of curious cases on record of what might be called collusion between comets. Take, for example, the events at the Vienna Observatory on the night of November 16-17, 1890.

The astronomer on duty was a 31-year-old assistant, Rudolf Spitaler, who later became a professor at Prague. At 2:30 a.m. he received a telegram from T. Zona, director of the observatory at Palermo, Sicily, announcing the discovery on the previous night of a fairly bright comet in Auriga. Spitaler pointed the 27-inch Vienna refractor at the approximate sky location given in the telegram, and on his first glance into the eyepiece saw a cometary object. He then set to work making repeated filar-micrometer measurements of its position relative to a neighboring star.

To his surprise, the motion was much slower than it should have been for Zona's object, and the comet was fainter than the telegram had led him to expect. It finally occurred to Spitaler that he had been observing a new comet, so he promptly explored the neighborhood and found Zona's comet little more than a degree away.

This was not unlike the experience of George Van Biesbroeck, at Yerkes Observatory on November 17, 1925. He had for some time been engaged in a series of observations of Comet Orkisz 1925c, detected that April in Poland, but which had since faded to magnitude 13. When Dr. Van Biesbroeck set the 40-inch refractor on the predicted position, he saw a fine 8th-magnitude comet in the field of the 4-inch finder! Officially designated 1925j, the new object was widely observed, and turned out to have a hyperbolic orbit.

A variation on this theme is provided by the story of Honoré Flaugergues' comet, 1826 III. Flaugergues was an amateur astronomer of Viviers, in southern France, who became well known for his numerous observations of eclipses, comets, and Jupiter's satellites, but he is chiefly remembered as the first man to see the great comet of 1811. To his contemporaries, he was enough of an astronomer to be elected a corresponding member of the Paris Academy of Sciences, and to be offered the directorship (which he declined) of Marseille Observatory in 1810.

Flaugergues received a letter from Jean Gambart of Marseille, telling of the finding of a new comet on March 9, 1826 (it later turned out to be a return of Biela's). Using a very small telescope, he located it with some difficulty on March 29th, "under the left arm of Orion." On several other evenings to April 5th, he made rough sketches of its location with respect to field stars. Realizing that the comet was being more effectively studied by other astronomers with better optical means, he did not examine his notes carefully until months later.

But then, on reading a detailed report in Baron von Zach's *Correspondence Astronomique,* Flaugergues realized that his own crude positions gave quite a different path across the sky, and he belatedly announced his discovery of a new comet. No one else ever reported seeing this object, 1826 III.

Early in 1914 a young German astronomer, W. Hassenstein at Strassburg, looked into this story.* Borrowing Flaugergues' record books from the archives of Paris Observatory, he studied the original sketch maps of 1826 III and its surrounding stars. His surprising conclusion was that on every night the French astronomer had misidentified the star fields, which actually matched configurations along the path of Biela's comet! Thus 1826 III had no existence of its own, and the observations really referred to Biela's.

JOSEPH ASHBROOK

*For the details of Hassenstein's detective work on 1826 III, see *Astronomische Nachrichten, 198,* 449, 1914.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 101st meeting of the American Astronomical Society at Gainesville, Florida, in December, 1958. Complete abstracts will appear in the Astronomical Journal.

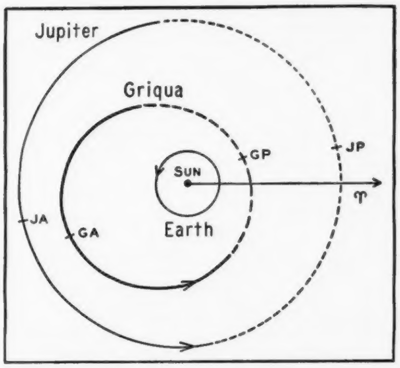
Orbital Motion of Griqua

Although thousands of asteroids revolve around the sun between the orbits of Mars and Jupiter, few of them have periods that are simple fractions — such as one-third, two-fifths, one-half — of the period of Jupiter. In the accompanying graph of the relative numbers of asteroids with various periods, there are well-marked "Kirkwood gaps" corresponding to periods commensurable with Jupiter's. There are few asteroids in the Kirkwood gaps, and one of the more recent attempts to explain this puzzling phenomenon has been reported on page 398 of the July, 1956, Sky and Telescope.

Eugene Rabe, of the University of Cincinnati Observatory, finds that during 1943 the faint asteroid Griqua (minor planet 1362) passed through the prominent Hecuba gap, when its 5.93-year period was half that of Jupiter. The asteroid provides a favorable opportunity to determine the mass of the giant planet, for the latter's perturbations are cumulative and can increase to very large values.

Therefore, Dr. Rabe has made detailed calculations of the orbital motion of Griqua from 1933 to 1975, taking into account the attractions of the principal planets from Venus to Neptune. During this 43-year interval, the semimajor axis of Griqua's orbit will have decreased from 3.284 astronomical units to 3.244, while the period of revolution will have shortened by 40 days. At the same time, the orbital eccentricity will increase from 0.34 to 0.36.

Because of the large orbital eccentricity, Griqua passes relatively near to Jupiter every 12 years, at a distance of about 220 million miles. The periodic repetition of the relative positions of the two celestial bodies increases the effectiveness of Jupiter's attraction in modifying the asteroid's orbit.



The orbits of Jupiter and minor planet 1362 Griqua are here projected on the plane of the earth's orbit. The halves of their orbits lying below that plane are dashed. The perihelion and aphelion points of Griqua's path are marked GP and GA, respectively, with JP and JA for Jupiter. Because Griqua's orbital plane is inclined about 23 degrees to Jupiter's, the approach to the giant planet is not as close as this diagram implies, and an encounter catastrophic to the asteroid cannot occur.

At perihelion, Griqua comes within 195 million miles of the sun. When perihelion and opposition occur on nearly the same date — as will happen in 1959, 1965, and 1971 — it is possible for us to observe this asteroid at a distance of less than 120 million miles. This proximity considerably increases the accuracy with which the orbital changes can be determined observationally.

Dr. Rabe's calculations show that for such a critical case as Griqua's, the perturbations in orbital longitude are not limited to any maximum amplitude. This was illustrated by two sets of ephemerides for the coming perihelion oppositions, one set including the planetary perturbations since 1935, the other computed as if no disturbing forces were present. As seen from the earth at such times, the asteroid's apparent positions in the sky predicted by the two ephemerides will differ by 26 degrees in 1959, by 43 degrees in 1965, and by 61 degrees in 1971!

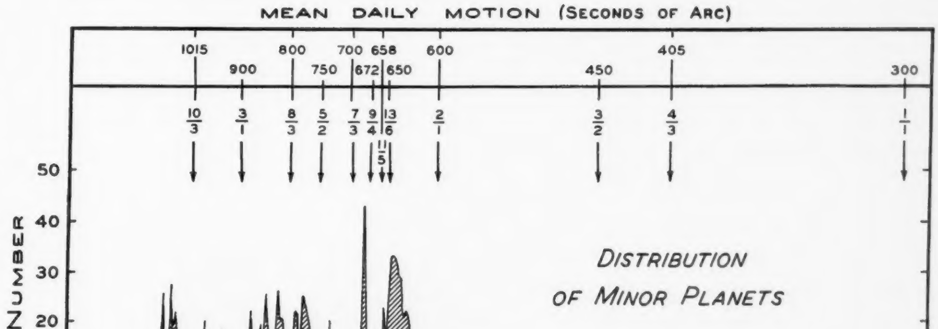
Considering the enormous and continuously increasing size of these displacements caused by Jupiter's gravitational force, Griqua seems to be a most suitable asteroid for the determination of Jupiter's mass. Dr. Rabe urges astronomers to make numerous accurate measurements of this minor planet's positions during the coming decades. Extended ephemerides will be published by Cincinnati Observatory, and all suitable observations will be analyzed there. Dr. Rabe expects to obtain an independent value of Jupiter's mass, equivalent eventually in accuracy to determinations from that planet's satellites.

Faint Variable Stars in Galactic Nebulae

Clouds of interstellar matter and certain types of faint variable stars are closely related. In fact, T Tauri- and Orion-type variables never occur outside galactic nebulae. But a comparison of the relative distribution of these stars by Edwin B. Weston, Amherst College and Smith College observatories, reveals distinct differences from nebula to nebula.

Considering only single interstellar clouds and not the larger cloud complexes, two extreme cases are observed in the distribution of faint emission-line and variable stars: 1. They may appear concentrated, in the absence of any very hot, highly luminous star, about the edge of

The average distances from the sun of the first 1,563 asteroids are plotted here. Fractions indicate the ratio of Jupiter's period to those of asteroids; for simple ratios like 3/1, 5/2, and 2/1, there are marked minima in the distribution. These are Kirkwood's gaps, and the one at 2/1 is sometimes known as the Hecuba gap. The comparative emptiness of the right half of the diagram is partly due to the greater difficulty of discovering the more distant and hence fainter minor planets. Yale Observatory chart.



The reflection nebula NGC 7023, enveloping a hot 7th-magnitude star, is surrounded by extensive dust clouds. In the bright nebulosity can be seen many faint variables with emission spectra. The stars grouped at the right are distant ones, observed through a transparent region of the dust cloud. W. T. Whitney used the McDonald Observatory 82-inch reflector for this photograph.

a cloud of dust and gas of high opacity. 2. They may be concentrated around a hot, highly luminous star embedded in a bright nebula. Intermediate situations are found, dependent upon the temperature and luminosity of the brightest star involved in the cloud and upon how long it has been shining with its present characteristics.

Examples of the first case include the region about RU Lupi, several other dark clouds in Lupus, the nebulosity containing R and S Coronae Australis, and several dark clouds in Taurus. The high opacity of such a dust-filled nebula hides from our view all intrinsically faint stars except those that are on the cloud's periphery. But at the opposite extreme, in the region around S Monocerotis, in the Orion nebula, and in NGC 7023 (a reflection nebula), we see the effect of radiation pressure of a very hot, luminous star that has "blown" the interstellar dust outward, thus decreasing the obscuration and revealing the faint stars in the deep interior of the cloud. Presumably the nebular gas, dragged along by the dust, also has a considerably reduced density.

In interpreting these observations, Mr. Weston makes use of the general differences in the two types of faint variables involved in such nebulosities. T Tauri stars are irregularly variable in both light and spectrum, the latter always exhibiting emission lines and, in extreme cases (such as S Coronae Australis), resembling the flash spectrum of the sun. An absorption spectrum, if observable, is like that of a dwarf of late spectral type, but the lines are broader and the star is brighter than a corresponding main-sequence object. On the other hand, the Orion variables have spectra suggesting spectral types from as early as *A* (possibly even *B*) all the way to late *M*. If properly classified, stars in this category should not show the marked spectral characteristics of the T Tauri objects, and on some occasions may have no emission lines at all.

It has been suggested that the unusual T Tauri characteristics may result from the accretion of matter from the nebulosity with which these stars are always associated. Mr. Weston points out that only in case 1, where no hot luminous star is present, are T Tauri variables with the more extreme characteristics found. And while Orion-type variables are present in case 1, they are far more common in case 2, where a hot star has developed, dispersing the dust essential to continued T Tauri activity. An object already formed near such a star in a dust-free nebula can no longer evolve into an extreme T Tauri type, but sufficient gas may still be present to give it an Orion type of spectrum. Perhaps the Orion variables represent a transition stage in the evolution of T Tauri stars into dwarf flare stars or other objects near the main sequence in the Hertzsprung-Russell diagram.

Cepheids in the Galaxy

It has long been known that in the Magellanic Clouds the Cepheid variable stars in the outer regions tend to have shorter periods than those in the central parts. Sidney van den Bergh, now at David Dunlap Observatory, described work done at the Perkins Observatory to see if Cepheids in our own galaxy are distributed in a similar fashion.

That the arrangement of these stars in the Milky Way galaxy is not uniform is shown by the graphs opposite, for all Cepheids fainter than photographic magnitude 11.0, within 10 degrees of the galactic equator, that had been discovered up to 1956. Four directions are selected: toward the center of the galaxy, toward the anticenter (in Taurus), and 90 degrees on either side of the center (plotted together) toward Cygnus and Carina.

Almost all the distant Cepheids in the direction of the center have periods longer than 10 days, with many about 15 days, while Cepheids with periods between two and eight days are quite rare. On the other hand, the short-period objects dominate the distribution in the direction of the anticenter, with the most frequent period being only four days. The distribution in the Cygnus and Carina directions is intermediate between those of the center and anticenter directions.

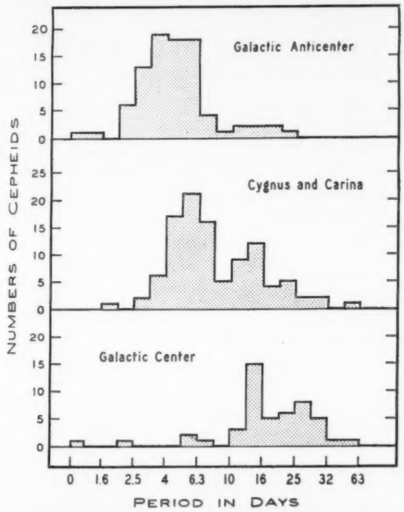
One complication in interpreting these

This region in Corona Australis is rich in nebular variable stars. The large bright nebulosity is NGC 6726-7, masking the variable S Coronae Australis. In the center of the picture is a tiny comet-shaped nebula, NGC 6729, at whose tip is the star R Coronae Australis, which varies irregularly between magnitudes 10.0 and 13.6. This photograph was taken in 1946 by W. T. Whitney with the McDonald Observatory 82-inch reflector, using a panchromatic plate without a filter.

differences is that the galactic Cepheids are a mixture of both classical (Population I) and Population-II variables. For instance, the 15-day Cepheids that predominate toward the galactic center should almost certainly be assigned to Population II — typical of the region of the galactic nucleus. However, those Cepheids with periods from 3.5 to 10 days are almost exclusively of the classical variety.

Therefore, in order to deal mainly with stars of a single type, Dr. van den Bergh restricted his subsequent study to the Cepheids in the period range from two to 10 days. With the aid of the period-luminosity relation, he calculated the distances of individual variables, assuming that each star's light was dimmed by one magnitude for each 1,000 parsecs of intervening interstellar dust.

To show the striking difference in classical Cepheid distribution, two groups were chosen for the accompanying maps:



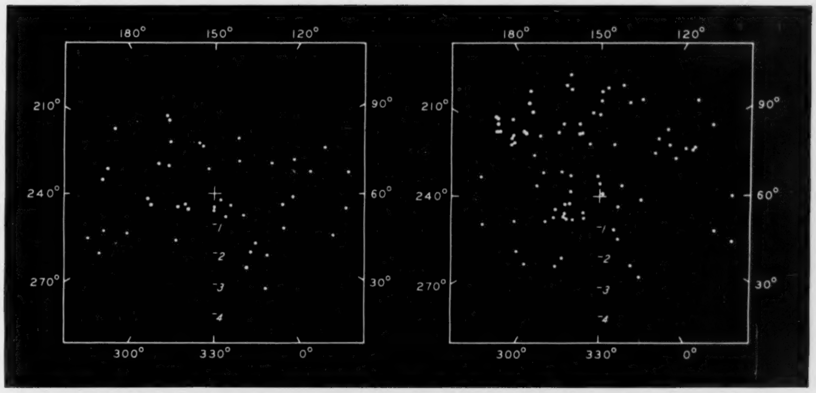
Diagrams by S. van den Bergh compare the periods of Cepheids in different portions of the Milky Way. Toward the center, periods tend to be longer than in the opposite direction, while Cygnus and Carina present an intermediate situation.

one for periods from two to four days, the other for periods of seven to nine days. It is evident that the majority of the Cepheids with periods around eight days are located in the hemisphere of the sky toward the galactic center. The stars with periods of near three days, however, tend to be situated in the opposite hemisphere — toward the anticenter.

Particularly striking is the strong concentration of two-to-four-day stars at about 10 to 12 kiloparsecs from the galactic nucleus, much farther out from the center of the galaxy than the sun is. This distribution is very similar to that found for Cepheids of short period in the two Magellanic Clouds. Dr. van den Bergh believes that this arrangement may have the same explanation in all three galaxies.

As stars evolve, they build up helium and heavy elements which are eventually ejected into interstellar space. Thus, in a region containing many evolving stars and little gas, the interstellar medium will become greatly enriched with heavy elements. But it will remain poor in these elements if there are few evolving stars and much gas. In our galaxy as well as in the Magellanic Clouds, the former case holds for the central regions, and the latter for the outer parts.

The mean periods of Cepheids will depend on the evolutionary tracks of the individual stars, and on the position of their region of instability in the Hertzsprung-Russell diagram. Both of these may be affected by changing the abundance of helium and heavy elements. Therefore, Dr. van den Bergh tentatively suggests that the dependence of Cepheid periods on distance from the galaxy's center may be due to some radial variation in the abundance of the heavy elements in the interstellar medium from which the Cepheids were formed.



Cepheid distributions (longer periods at left) projected on the plane of the galaxy. The sun is shown by the central cross, and the numbers mark distances in kiloparsecs from it toward the galactic center (downward).

Large Planetary in Norma

A diffuse nebulosity, NGC 6164-65, first noticed by Sir John Herschel in 1834, has been tentatively identified by Karl G. Henize, Smithsonian Astrophysical Observatory, as a planetary nebula. If the classification is correct, this object is the fourth largest in angular size and one of the nearest of all planetaries.

Objective-prism photographs taken in red hydrogen light, during a survey conducted by Dr. Henize in South Africa for the University of Michigan and Mount Wilson observatories, show the gas to be distributed in a markedly symmetrical fashion about the star HD 148937 (1950 position, $16^h\ 30^m.2$, $-48°\ 0'$). As the direct photograph indicates, the nebula is roughly shaped like a figure "8," and bright parts in the nebulosity are symmetrical about the central star.

If this star, of spectral type *B*0, is a normal main-sequence object, its estimated distance is 670 parsecs, based on its proper motion, spectrum, and apparent magnitude of 6.9 (brighter than any other planetary's central star). As the apparent diameter of the nebula is 6.2 minutes of arc, its linear size would be 1.2 parsecs at that distance.

However, it seems more likely that the central star is a subluminous *B* or *O* star comparable to those in other planetaries. In this case, the distance is only 150 parsecs, and the linear diameter 0.27 parsec. Careful spectroscopic observations of the nebula and central star are needed to indicate which values are correct and to verify the preliminary classification of NGC 6164-65 as a planetary nebula.

This gaseous nebula surrounding a 7th-magnitude star in the southern sky has recently been identified by K. G. Henize as a hitherto unrecognized planetary nebula. In this photograph taken with the 48-inch Schmidt telescope, north is upward and east to the left. The bright southeastern part is NGC 6165, and the fainter northwestern portion is NGC 6164. The long diameter of the nebulosity is 6.2 minutes of arc. Mount Wilson and Palomar Observatories photograph.

Eclipse Photographs from the South Pacific

At Suwarrow Island, a remote tropical islet in the central Pacific Ocean east of Samoa, Japanese astronomers from Tokyo Observatory set up their equipment. This equatorial mounting carried an array of cameras to determine the polarization and other characteristics of the sun's corona.

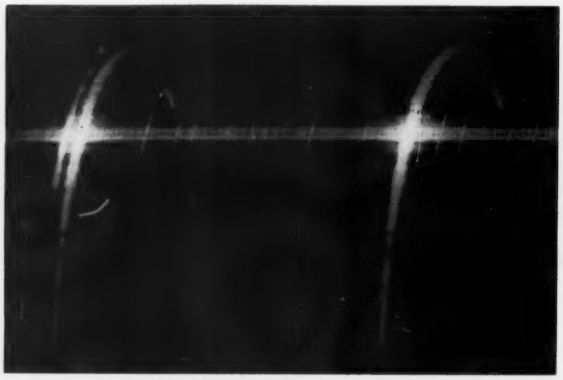
AMONG expeditions in the Pacific favored by good weather for the total solar eclipse last October 12th were the Japanese group on Suwarrow Island and a party of English and New Zealand scientists on the island of Atafu, north of Samoa (see SKY AND TELESCOPE, December, 1958, page 68). At both sites varied observations were made, particularly of the solar corona.

The Japanese equipment included two four-camera clusters attached to the same equatorial mounting, as shown in the photograph. These were used by Drs. Yamashita and Shimizu to study polarization in the corona. In one set, each camera had a long focal length — 230 centimeters — and an aperture of 90 millimeters, but two were stopped down to 30 millimeters. The other cluster consisted of four f/4.5 cameras of 65-millimeter aperture, with small neutral focal-plane filters to mask the bright inner corona so that the outer corona would be visible.

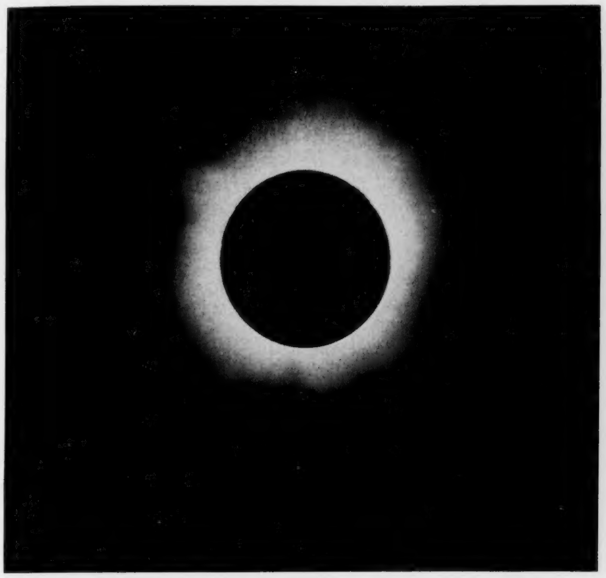
During totality, exposures of $\frac{1}{2}$, 5, 45, and 60 seconds were made with the short-focus instruments, and five-second exposures with the others. It should be possible to measure the polarization of the corona to a distance of 30 solar radii from the limb of the sun on the short-focus photographs and to seven solar radii on the long-focus plates.

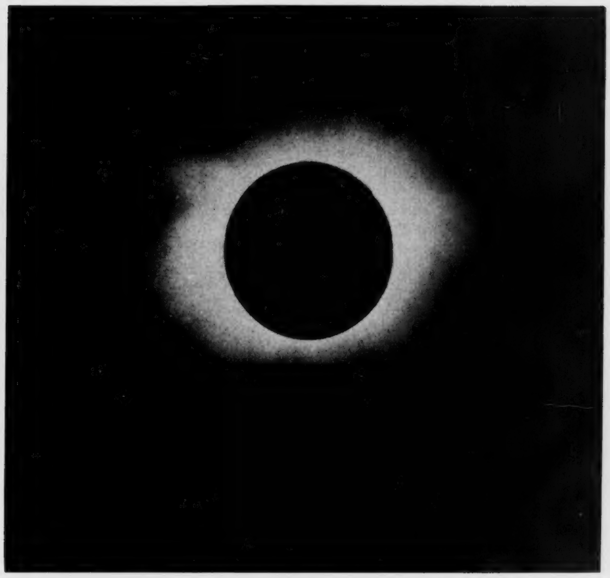
Also on Suwarrow Island, Drs. Tanabe and Kato employed an f/4.8 Aero-Nikkor lens of 50-centimeter focal length for a photoelectric survey of the outer corona and zodiacal light. The instrument was equipped with rotating blue, yellow, and polaroid filters. In addition, these observers made photoelectric measurements of the airglow during totality, using a rotating polaroid set behind a birefringent filter, so that the effective wave length was continuously changed. The D lines of atmospheric sodium and other emission lines at 6300 and 5577 angstroms were measured.

In another important Japanese program, the flash spectrum, which is seen at the beginning and end of totality, was observed by the method of grazing inci-



A small section of the flash spectrum at the 1958 eclipse, recorded by Japanese astronomers. Each bright arc is an image of the glowing solar chromosphere in one spectral line: left to right, hydrogen-epsilon, and the H and K lines of ionized calcium (widely separated).





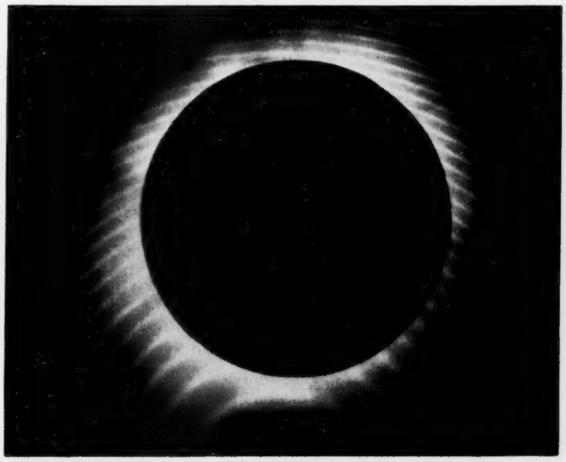
The solar corona during totality on October 12, 1958, as photographed at Suwarrow Island. Polaroid filters were placed so the plane of polarization (defined by the orientation of the magnetic vector) is vertical in the left picture and horizontal in the other. The conspicuous differences demonstrate a marked degree of polarization of coronal light. Short gray lines indicate north with respect to the center of the sun.

dence. A 30-cm. coelostat and auxiliary mirrors fed the image of the sun to a Bausch and Lomb replica grating ruled with 1,200 grooves per millimeter (30,500 lines per inch). The light from the chromosphere met these rulings at a very oblique angle; hence the spectral images of the sun's edge were elliptical in shape, rather than circular as in a conventional flash spectrum.

The enlargement shows this effect: the lengths of the axes of the image ellipses of the H and K calcium lines, for example, are four and 20 centimeters, the shorter axis being parallel to the dispersion. Thus, even the whole visible depth of the chromosphere, about 10 seconds of arc, is jammed together into a narrow line with a width of less than 0.2 millimeter in the direction of the dispersion. This permits measurement of line profiles without difficulties from the depth of the chromosphere, as would be the case for the ordinary technique.

With this equipment, Drs. Suemoto and Hiei used 800 feet of film to obtain 280 exposures from 1/25 second to 10 seconds in duration. Near totality an 0.7-second exposure was made each second. Thin clouds affected the results at the middle of totality and near third contact.

On Atafu, somewhat earlier in the day, Dr. H. von Klüber, University of Cambridge, made interferometer observations of spectral lines in the solar corona. One of his pictures is reproduced here, of the corona in the light of its 5303-angstrom emission line, due to iron atoms that have lost 13 electrons. The photograph was taken with a Fabry-Pérot interferometer, containing two parallel glass plates, which produced strong interference fringes. Measurements of the intensity distribution in these fringes will permit evaluation of the profile of the 5303 line, which can be used in deducing the temperature and density of the corona.



This interferometer picture of the corona was obtained at Atafu by H. von Klüber. The bright fringes were formed by parallel glass plates in the optical path. Analysis of their pattern will give information about physical conditions in the outer atmosphere of the sun.

NEW ULTRAVIOLET PRISM FOR CASE SCHMIDT

Astronomers of the Warner and Swasey Observatory in Cleveland will now be able to study extremely hot, blue stars with the aid of a new objective prism that is transparent to ultraviolet light. Two feet in diameter and weighing 72 pounds, the prism will be carried at the top of the 24-inch Schmidt telescope at the Case Institute of Technology's Nassau Astronomical Station, near Chardon, Ohio.

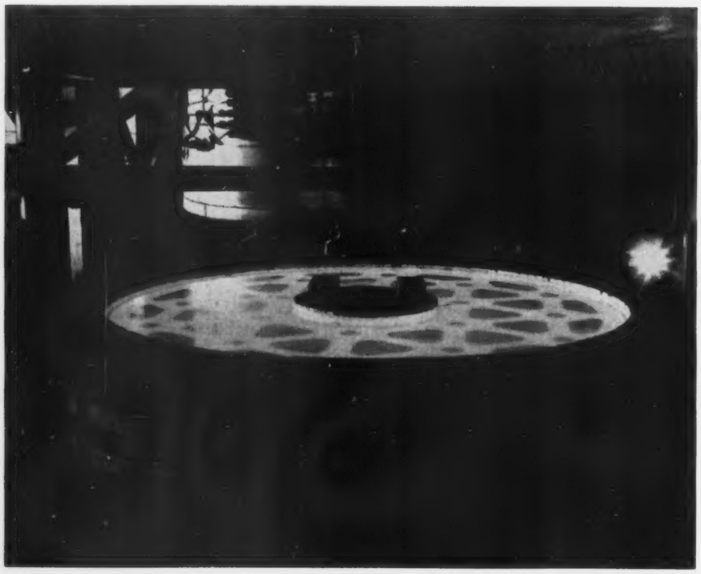
The prism is made of special imported glass, known as Schott UBK-7, which passes the shorter wave lengths of light. The Case Schmidt is one of the few having a correcting plate that is transparent to ultraviolet light, and with the prism will enable extension of the Warner and Swasey spectroscopic program to short wave lengths.

With a grant of $10,500 from the National Science Foundation, the prism was fabricated by Perkin-Elmer Corp., and mounted by Warner and Swasey Co.

CORRECTIONS

In the November, 1958, issue, in the first paragraph of the second column on page 11, Dr. Peter van de Kamp was reported to have been appointed chairman of the IAU commission on proper motion and parallaxes. He was actually appointed chairman of the double star commission.

Jay H. Respler, of New York City, points out that the rocket shown on page 244 of the March issue is not the same as the one on page 246. A comparison of the photographs reveals their differences, the first being the Thor-Able used for Pioneer II, and the second the modified Jupiter of Pioneer III.



Kitt Peak Observatory's 84-inch Mirror Cast

A HONEYCOMBED pyrex glass disk seven feet in diameter, 13 inches thick, and weighing over 3,500 pounds, is now being cooled in a special oven at the Corning Glass Works in upstate New York. It is the largest glass blank to be cast for a telescope mirror since completion of the 200-inch disk some 25 years ago.

Six months of planning and engineering preceded actual making of the blank early this year, and it will remain for seven months in the annealing kiln. Destined for the National Astronomical Observatory's 84-inch reflector on Kitt Peak in southern Arizona, the blank will be shipped to Tucson this summer.

Nine separate pieces of glass were melted down at 2,300° Fahrenheit in a process known as sagging. Although disks up to 72 inches in diameter have been cast by this method, these were solid blanks without ribbing. Such mirrors as the 200-inch have been made by ladling molten glass into the mold, but the new method is cheaper and reduces bubbles in the glass.

One of the major tasks was building the mold for the ribbed structure. Corning engineers followed the work of George V. McCauley, who had supervised casting of the 200-inch blank and had worked out the design for the ribbing. Each core, made of ceramic brick, was precisely placed with templates, then cemented and bolted in position. A special cooling system prevented the bolts from melting while the disk was being formed.

The uppermost picture shows craftsmen placing the ceramic cores. The central one was 26 inches in diameter, forming the mirror's central perforation (for Cassegrainian optics). The other cores were round, triangular, and kidney-shaped, to form the proper surfaces against which the mirror's flotation system would support the mirror in its cell.

In the center picture, the chunks of glass are in position, the largest piece of 2,796 pounds resting on the center core, which was reinforced beneath by steel. But shortly after the furnace began heating up, this big piece of glass developed a crack. Since an early breakage of any sections of the glass might damage the delicate cores, the melting process was halted while the loosening pieces were sliced off and placed in new positions around the mold.

The melting then proceeded satisfactorily. An extra 48 hours of heating was used to eliminate slight bubbles, and the disk was then removed from the kiln. The lowest picture shows the transparent molten glass, glowing with an orange light, on its way to the annealing kiln. In the latter, the temperature was to be held constant for two months, then lowered at the rate of about one degree centigrade per day. This long cooling is essential to prevent stresses and strains from being set up in the glass.

Standard equipment could not be used for this entire operation. Part of the special equipment included the huge táble on which the mold rests, the latter actually forming the bottom parts of the furnace and annealer. The table was raised to shut tight these enclosures. It was moved along two rails into the dome-shaped furnace and to the annealer.

Once the disk reaches Tucson it will be ground and polished. If past experience with large mirrors is any guide, it may be several years until the last small corrections to its figure are complete. Preliminary plans for the new observatory were given on page 493 of the August, 1958, issue of SKY AND TELESCOPE.

OBSERVING THE SATELLITES

VANGUARD II

FIRST of a new series of artificial satellites for weather research, Vanguard II entered into a long-lived orbit on February 17th at 16:05 Universal time, 10 minutes after the three-stage rocket carrier rose from its Cape Canaveral launching pad.

This 22,600-pound rocket assembly was 72 feet long and 45 inches in diameter at its base. Liquid oxygen and kerosene powered the first stage for 130 seconds, after which the next stage operated for 110 seconds, using nitric acid and unsymmetrical dimethylhydrazine as fuel. This stage contained the complete guidance and control system that directed the gimbal-mounted engines of the first two stages, and that jettisoned the protective nose cone during powered second-stage flight.

Then, during five minutes of upward coasting before the second stage was separated, the rocket was given a spin of 180 revolutions per minute to stabilize its orientation. At the programmed height, the solid-fuel third-stage engine was ignited, and within about a minute the velocity had reached approximately 18,300 miles an hour. The instrumented satellite was thrust away from the burned-out final stage at a relative speed of about four feet per second, and the two objects began moving through space in closely similar orbits. Their period of revolution was initially 125.9 minutes. The satellite itself is designated 1959α1, while the last-stage carrier rocket is 1959α2.

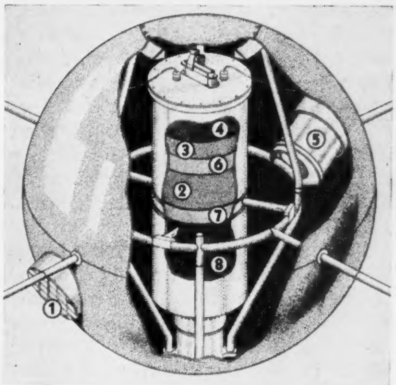
The 21-inch, 23-pound spherical satellite was expressly intended to observe the changing large-scale distribution of cloud masses over the earth's surface, in a program of the National Aeronautics and Space Administration. The aim was to provide a broad picture of the cloud cover, rather than its fine details. Seen from above, clouds reflect about 80 per cent of the sunlight falling on them, but land and sea areas are much darker, reflecting only 15 to 20 and five per cent, respectively.

The scanning apparatus was devised by the Army Signal Research and Development Laboratory at Ft. Monmouth, New Jersey. Two photocells, sensitive primarily to infrared radiation, receive the light collected by a pair of 3-inch parabolic mirrors. These scanners are mounted on opposite sides of the sphere, at a 45-degree angle to its spin axis, and at least one photocell scans the earth 50 times per minute when the satellite is lowest.

Each mirror's field of view is slightly more than one degree, covering about seven miles on the earth's surface when the satellite is at perigee, 347 miles high. A sweep of a scanner from horizon to horizon is then some 600 miles long; at apogee, the satellite rises to about 2,065 miles, but this was always over the nighttime side of the earth during the limited lifetime of the transmitting batteries. The inclination of the satellite orbit limited the scans to latitudes from about 35° north to 35° south.

Data from the scanners was accumulated on a 75-foot loop of $\frac{1}{4}$-inch magnetic tape, which could be played back through a radio transmitter operated on command from one of six ground stations. Such telemetering required only a 60-second burst, during which the tape automatically erased itself to be ready for further observations. The ground stations are in Georgia, California, Peru, Australia, and two in Chile.

The satellite's one-watt telemetering transmitter operated at 108.03 megacycles, until its mercury batteries ran down (about the middle of March). To prolong their life, the tape recorder was shut off by solar batteries whenever the satellite was in the earth's shadow.



This cutaway sketch of the Vanguard weather sphere shows: 1, photocell window; 2, tape recorder; 3, radio receiver; 4, transmitter for meteorological data; 5, parabolic mirror and photocell; 6, electronic components; 7, tracking transmitter; and 8, mercury-cell batteries. U. S. Army picture.

For radio tracking, a second, low-power transmitter sent a continuous signal which was recorded by Minitrack stations. A heat-sensitive crystal in this transmitter indicated the temperature within the satellite as averaging +86° Fahrenheit during the initial revolutions, the extremes being +50° and +140°.

The first optical observations were made during the tenth revolution around the earth, when successful photographs were taken with the Baker-Nunn camera at Woomera, Australia. On the same evening, February 18th, a team of visual observers at China Lake, California, detected the satellite with 120-mm. telescopes. The 21-inch sphere is a faint object, being reported as magnitude +8 or +9.

The spent carrier rocket, 1959α2, is a 51-pound cylinder, 57 inches long and 18

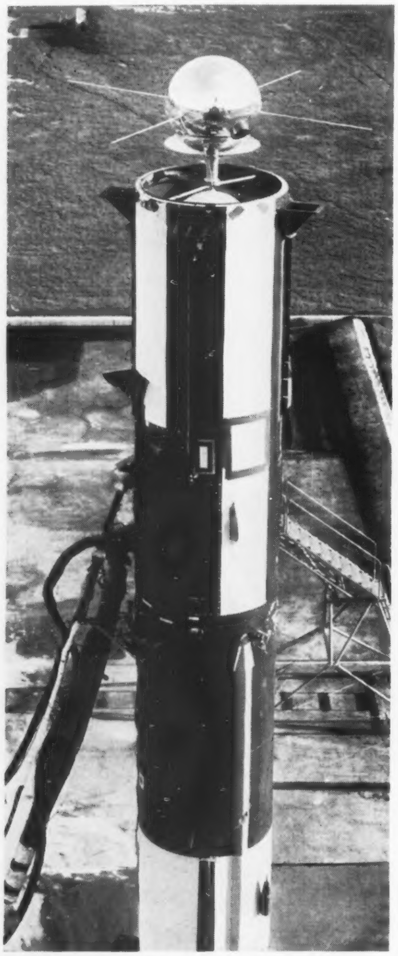
Left: Compare this closeup of the Vanguard instrument package with the sectional view at the top of this page.

Right: During final assembly, the upper half of the satellite's brightly polished shell is being lowered into place by technicians. Note the arrangement of the interior to provide dynamic balance of the components around the spin axis. U. S. Army photographs.

in diameter. There were not enough optical observations of this body to establish its orbit until more than a week had passed. It could then be ascertained that the initial period of the rocket was 4.7 seconds shorter than for the sphere. The rocket has been reported as magnitude +7, but because of its tumbling we may expect it to be sometimes much fainter.

By February 26th, the spherical satellite had completed 108 revolutions around the earth, and on 96 of these its weather reports were successfully received, according to an NASA spokesman. Nearly all of the 12 exceptions represented failures of the ground stations rather than of the satellite. From these observations it was planned to construct maps of the earth's cloud cover, after the data had been reduced.

The most recent information about the orbit of the sphere made available by NASA indicates that on February 24th at 18^h Universal time the perigee-to-perigee period was 125.853 minutes, shortening by 0.027 second per day. The orbital inclination was given as 32.87 degrees.



Vanguard II rests atop its launching vehicle at Cape Canaveral, just before the protective nose cone is put in place. NASA photograph.

Another Artificial Planetoid

On MARCH 4th, at 22:24 Universal time, a cone-shaped 13.4-pound instrument package passed within 37,000 miles of the surface of the moon and traveled on into the solar system, to become a satellite of the sun. Thus, both the United States and the Soviet Union have projected missiles into interplanetary space, the Russian "Mechta" having passed the moon on January 4th (page 197, February issue).

According to press accounts, Pioneer IV, as the American projectile is called, was to reach perihelion on March 17th, 91,750,000 miles from the sun (about the same distance as the earth's perihelion). Then it will travel outward to aphelion on September 29th, when its solar distance will be 105,830,000 miles. The eccentricity of the orbit is about seven per cent, whereas that of "Mechta" is nearly 15 per cent. The period of orbital revolution of Pioneer IV is 392 days.

The launching took place at Cape Canaveral, Florida, on March 3rd, by means of a 60-ton four-stage Army Juno-II rocket. This imparted a top speed of 24,791 miles per hour to the gold-coated probe. Although this was 194 miles per hour less than intended, escape velocity was exceeded by 200 miles an hour. The small discrepancies in velocity and direction prevented the Pioneer from passing as close to the moon as planned. The increased distance appears to have caused nonoperation of a photoelectric sensing device, which was to have been triggered by the reflected light of the moon. However, an arrangement intended to slow down the vehicle's spin functioned satisfactorily.

Pioneer IV contained instruments to record radiation intensities in the Van Allen belt. Such data were being radioed back to earth, but their detailed analysis will require some time. There was no indication that the space probe had passed through any clouds of high-energy particles ejected from the sun.

A solar orbit closely similar to that of the 20-inch probe is undoubtedly being followed by the spent fourth-stage Sergeant rocket, which could not be tracked. This had provided the final launching thrust that ended about $4\frac{1}{2}$ minutes after the take off on March 3rd at 05:10:30 Universal time. Radio signals from the probe's 0.18-watt radio transmitter operating at 960.05 megacycles were successfully received until "artificial planet 2" had receded to 410,000 miles from the earth.

Discoverer I

An artificial moonlet was fired southward into a polar orbit from Vandenberg Air Force Base, California, on February 28th at 21:49:15 Universal time. The novel launching was under the auspices of the Advanced Research Projects Agency of the Department of Defense.

Malfunctioning of its radio transmitter led to much uncertainty during the following days as to whether Discoverer I had actually attained orbit. Because the launching took place shortly after noon, optical observations were impossible except from the polar regions, for reasons given on page 260 of the March issue. Months would pass before such a satellite could become visible from the middle latitudes, but the expected orbital lifetime of Discoverer I is only about five weeks.

The entire second-stage rocket, 18.8 feet long and five feet in diameter, weighing about 1,300 pounds after its fuel was spent, presumably entered into orbit $7\frac{1}{2}$ minutes after launching. The first-stage booster was a Douglas Thor intermediate-range ballistic missile, powered for $2\frac{1}{2}$ minutes by kerosene and liquid oxygen. After coasting for an equal length of time, thrust began in the Discoverer stage, which employed a Bell engine burning a spontaneously igniting mixture of hydrocarbons and fuming nitric acid.

According to reports issued by ARPA, it appears that the satellite was intended to be continuously stabilized with its long axis horizontal as it circled the earth. This would require the continuous application of power while in orbit.

However, the stabilizing system failed to function properly, and the tumbling of 1959β interfered with the reception of its highly directional radio transmissions by Air Force ground stations.

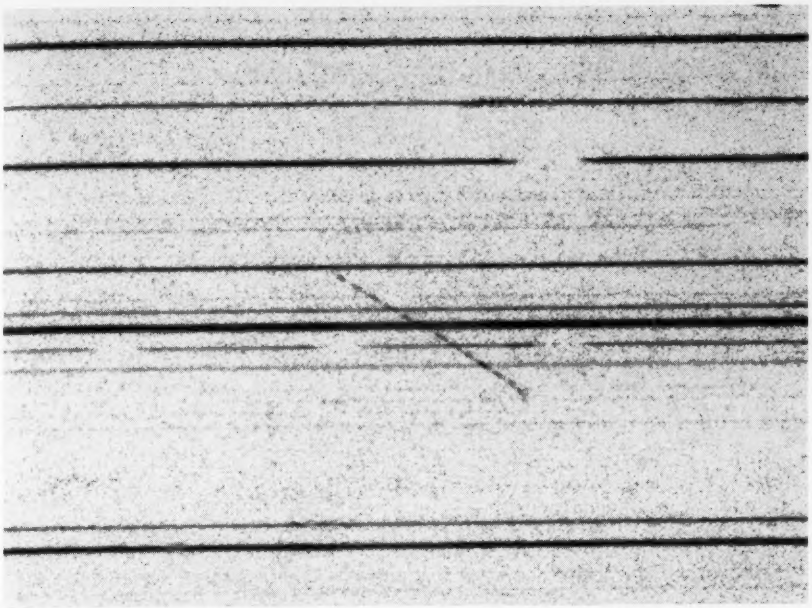
This vehicle was launched partly to try out its thrust and guidance systems, and partly to test the new Pacific Coast facilities. Plans announced by ARPA call for development of methods for returning satellites to selected areas of the earth. Small animals will be carried, to provide information for the man-in-space program of the National Aeronautics and Space Administration.

Searching for the Lost Rocket of Vanguard I

THIS MARCH 17th the high-flying Vanguard test sphere, $1958\beta2$, completed its first year in orbit. It continues to be tracked regularly, thanks to its still-active radio transmitter powered by solar batteries. The orbit is known with enough accuracy to permit predictions a month in advance.

However, $1958\beta1$, the rocket carrier that accompanied Vanguard I into orbit, is lost, in spite of the fact that it is much larger than the 6-inch sphere and should be readily visible at suitable times. April will provide favorable conditions for Moonwatch observers in the southern United States to search for it.

When the sphere was originally separated from the rocket carrier, their relative velocity was 0.95 feet per second, according to the Naval Research Laboratory. This corresponds to an initial difference in period of not more than one second per revolution. We also know



The first Baker-Nunn photograph of the Vanguard-I 6-inch sphere, taken January 10, 1959, at 2:20:54 Universal time, at Organ Pass, New Mexico. This satellite was then about 900 miles high. The exposure time was 19.3 seconds and the camera's primary driving rate was $17\frac{1}{2}$ minutes of arc per second of time, causing the stars to register as long streaks. The heavy trail crossing the satellite's short track is 12 Trianguli. Regular breaks in the track are presumably caused by rotation of the satellite, not the camera shutter. Smithsonian Astrophysical Observatory photograph.

from the dimensions of the two bodies that the average atmospheric drag on the carrier is at most 50 per cent greater than that on the sphere, whose period shortened by only 0.15 per cent during the year.

Calculations based on these facts show that the planes of the two orbits should nearly coincide; the ascending node of β1's orbit lies only one or two degrees west of the ascending node of β2. While we therefore know the approximate orbit plane of the carrier rocket, we cannot tell at what point in its orbit it will be at a particular time; the drag on the irregularly shaped rocket is not known accurately enough for that.

For an effective search, it is necessary that the orbit plane be suitably located with respect to the sun, and that the rocket be near its perigee, so it is not dimmed by great distance from the observer. (The angular distance from the ascending node to perigee may be at most three degrees larger for the rocket than for the sphere.)

The inclination of the orbit is $34\frac{1}{4}$ degrees, so the northern apex of the orbit plane is at a latitude of $34\frac{1}{4}°$. The nodes move westward 3.02 degrees per day, and the position of the apex moves similarly. On the evening of this April 14th, the Northern Hemisphere apex will cross the observer's meridian at about the end of nautical twilight, that is, when the sun is 12 degrees below the horizon. The situation will allow an observing group to man a fence of telescopes for the full duration of one revolution of Vanguard I, about 134 minutes, beginning as soon as the sky becomes dark enough.

At some time during this interval, 1958β1 will cross the sky, traveling from west to east. Its probable magnitude should be between +6 and +8, for its height above the ground at the apex will be nearly 500 miles. A few days later, on April 18th, the apex height will be about 415 miles, but this part of the orbit will lie much closer to the sun – about 15 degrees west of the observer at the end of nautical twilight. Furthermore the moon may interfere with observations, as it will then be gibbous, 10 days old.

But earlier in April, from about the 8th onward, conditions are the most favorable. The apex of the orbit plane reaches the observer's meridian about 110 minutes after the end of nautical twilight, and the expected ground height is around 700 miles. This height is just sufficient to permit sunlight to fall on the apex point of the orbit from the end of nautical twilight onward. By extending the fence southward, provision can be made to catch the rocket at a lower altitude as it moves northward toward the apex. Therefore, the observations should still begin at the end of nautical twilight. This general situation applies all through the week from April 8th to 14th.

On or about July 11th the Vanguard-I orbit apex will again be favorably situated with respect to evening twilight near latitude 35° north in the United States, and at that time the perigee point will lie very close to the apex.

The writer will be pleased to supply serious observers, who send a stamped reply envelope, instructions for computing the settings of telescopes so that the most favorable portion of the orbit is kept under view during an April observing session.

MARSHALL MELIN
Research Station for Satellite Observation
P. O. Box 4, Cambridge 38, Mass.

QUESTIONS... FROM THE S+T MAILBAG

Q. Are there any green stars?

A. No. There are a few reports published by early observers mentioning green stars, but this impression is known to be subjective.

Q. Which of the nine principal planets is the smallest?

A. Mercury, which has a diameter of 2,900 miles. The next larger planets are Pluto, 3,600 miles, and Mars, 4,200.

Q. What kind of time is referred to when it is said that 15 degrees equal one hour?

A. This refers to solar time if the sun's daily motion is involved and to sidereal time if a star is being observed.

Q. What is the prime focus of a telescope?

A. This is the place at which the telescope's mirror or lens brings the gathered light rays to a focus and forms an image without the use of secondary mirrors or lenses. This image may be examined with an eyepiece, photographed, or used for spectroscopy or photometry.

Q. During an eclipse of the sun, can the solar corona be seen if the moon does not completely hide the sun's disk?

A. No. Totality requires 100 per cent obscuration, for even very little light from the photosphere will blot out the corona, which is about one millionth as bright as the whole sun.

Q. What do the terms *inferior* and *superior* mean when referring to a planet or a conjunction with the sun?

A. Inferior planets have orbits within the earth's (Mercury and Venus), whereas superior planets are farther from the sun than the earth is (Mars to Pluto). Inferior conjunction occurs when a planet passes between us and the sun (only Mercury and Venus can do this). Superior conjunction is when an inferior planet is on the other side of the sun from the earth; for the superior planets this position is simply called conjunction.

Q. What is retrograde motion of a planet or asteroid?

A. It is an apparent westward movement among the stars, as opposed to the usual eastward motion. It occurs when the earth overtakes and passes a superior planet, or when an inferior planet passes the earth. W. E. S.

Some Astronomical Stamps—IV

ALPHONSE P. MAYERNIK

The Big and Little Dippers are realistic in the red and indigo design of this 44.75-lire, 1933 airmail of Cyrenaica, a former Italian colony that is now part of Libya.

The Big Dipper and its position with respect to the North Star have been carefully plotted on this handsome 15-cent gray Canadian pictorial of 1954.

OUR STAMPS this month are representative of a relatively large number that have constellations and stars in their designs. Although a few of these issues seem to have been put out for specific astronomical events, it is the general symbolic appeal of stellar configurations that has led to their use on the postals of many countries.

To incorporate constellations on stamps, the philatelic designer must cope with components that are small in relation to the spaces between them. The attempts have usually been successful, but sometimes the result has neither grace nor accuracy. For instance, compare the distorted Big Dipper sprawled over the Alaska statehood commemorative with the same star group on the Canadian stamp or on the 10-yen Japanese issue.

The most common star groups on stamps are the Big Dipper and the Southern Cross, whose impressive patterns have evoked much prose and poetic imagery. The Big Dipper is part of the Greater Bear (Ursa Major), associated with the Greek legend of Kallisto, a beautiful maiden changed into a bear by the jealous goddess Hera. Thus transformed, Kallisto was almost slain by her son Arcas. To prevent this tragedy, Zeus changed him into another bear (Ursa Minor) and placed them both in the

An olive-green and olive, 400 + 200 reis, Brazilian semipostal stamp of 1939. Compare this reversed representation of the Southern Cross with the more accurate configurations on the stamps of Australia (below left) and New Zealand (below).

Left: The Southern Cross is correctly proportioned on a 7½-pence ultramarine stamp of Australia, commemorating the 16th Olympic games held at Melbourne in 1956. Center: Issued in 1952 to publicize telecommunications, this 20-centime red-lilac and gray-blue Swiss stamp pictures a star cluster, and is one of a set of four with similar designs. Right: A violet-blue 6-pence New Zealand issue of 1958, marking the 30th anniversary of the first air crossing of the Tasman Sea between Australia and New Zealand, shows the Southern Cross.

This 7-cent United States airmail stamp is blue, while the 20-centavo Argentinian is olive-green, having been issued in 1951 to mark the 10th year of the state airlines.

sky. To satisfy Hera, Tethys (ruler of the sea) barred them from entering the water. This is why, according to the legend, they circle the pole without setting.

Although visible to the ancient Greeks, the Southern Cross was known only as part of the Centaur, being listed that way by Ptolemy in the 2nd century A.D. Owing to precession, this star group has become invisible from Europe. Augustin Royer, a Frenchman, was probably the first to describe Crux as a separate constellation, in 1679, although its four bright stars were mentioned by European voyagers at least 200 years earlier. Dante described them accurately in *Purgatorio:*

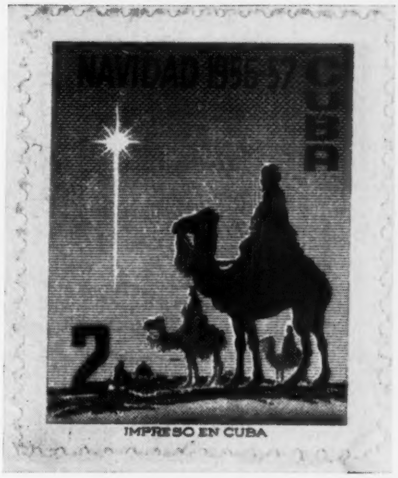
Al altro polo e vidi quatro stelle
Non viste mai fuor che alla prima gente,
(Upon the other pole and saw four stars
Ne'er seen before save by the primal people,).

Crux is compact, only eight degrees in length. Its brightest star, Alpha Crucis, at the top of the cross, is a fine multiple system with two 1st-magnitude components. An awe-inspiring feature of Crux is the great dark spot in the Milky Way called the Coalsack.

The Pleiades, depicted on a set of four Swiss stamps, were the seven daughters of Atlas in Greek mythology. Legend says they were placed by the gods among the stars and that all seven remained visible to men until Asterope faded away, from shame at having married a mortal.

The Star of Bethlehem appears on two Cuban stamps. It is still unknown what natural phenomenon may have been seen by the three magi in the Biblical story. Some popular suggestions are a supernova, a comet, a fireball, or a conjunction of planets (see SKY AND TELESCOPE, December, 1956, page 66).

(To be continued)



Two Cuban stamps of 1956 depict the Star of Bethlehem. The 2-centavo red and slate-green one is shown here.

At the left, the Big Dipper is pictured on a 10-yen dark green postal, while at the right the Southern Cross has a nautical setting on a 5-yen purple stamp. Japan issued them in 1952 to mark the 75th year of its membership in the Universal Postal Union. In the center is a symbolic view of Crux (when below the south celestial pole) on a 3-peso violet-blue 1954 stamp of Argentina, publicizing a telecommunications conference in Buenos Aires.

Amateur Astronomers

An Amateur Observatory in Honolulu, Hawaii

TWO MONTHS were required to construct the observatory pictured here. My wife and I worked continuously for five vacation weeks, and part-time for three more weeks. Our Marian Walley Observatory is located at latitude 21½° north, longitude 158° west, and accommodates an 8-inch electrically driven reflector.

The building has 12 sides, with a four-foot door and two windows. The concrete foundation is six inches thick, except for an 18-inch base under the telescope mounting. The hemispherical dome is 9.55 feet in diameter, so that one inch of rotation is one degree along the horizon. Four heavy clamps hold the dome in high winds. It sits on 14 rubber-tired 1½-inch wheels, with 14 more wheels keeping it centered. The shutter is also on rollers, and the 24-inch-wide slit extends 12 inches beyond the zenith for overhead viewing.

Materials for the observatory cost slightly over $400, including $32 for 2,000 screws, as all joints were glued, nailed, and screwed. All the wiring is underground.

During observing there is space for eight persons within the building, two at the telescope and six on folding chairs.

Mr. and Mrs. P. C. Walley have built this practical observatory in their Honolulu backyard.

Members of the Hawaiian Astronomical Society have a standing invitation to observe here every Friday night, weather permitting.

PAUL C. WALLEY
2951 Kuahiwi Way
Honolulu 17, Hawaii

COST OF FIELD TRIPS AT DENVER CONVENTION

A complete package of tickets for the three field trips planned at the Nationwide Amateur Astronomers Convention in Denver, Colorado, this August 28-31, will cost $11.00 per person. Reservations are now being accepted by Ned Onstott, 2421 Second Ave., Pueblo, Colo. Tickets for the individual trips are also available. Each tour is to be made by chartered bus only.

The first trip will be on Friday, August 28th, to the National Bureau of Standards and its radio telescope installations near Boulder (see page 304). On an individual ticket basis, this will cost $1.75.

The Air Force Academy tour and chuck-wagon dinner at Colorado Springs on August 29th (page 250, March issue) is priced at $5.75 for each amateur. A third field trip on September 1st, the day after the convention formally closes, is to the High Altitude Observatory in Climax, Colorado. The 220-mile eight-hour round trip is $4.25 per person, with buses scheduled to leave Denver at two-hour intervals with three different groups of delegates.

MOONWATCH MEETING IN CALIFORNIA

Eleven Moonwatch stations, in the area from Portland, Oregon, to Whittier, California, were represented by 39 amateurs attending the second Northern California Moonwatch convention on January 24th. Sponsored by the Walnut Creek team and held at Diablo Valley College in Concord, the informal meeting included a review of orbital calculations, methods for locating the earth's shadow, a graphical method of making precise predictions of meridian crossings, plans for short-wave communication, and summaries of each station's operations.

DONALD F. CHARLES
868 Audrey Court
Pleasant Hill, Calif.

Some members of the Pontchartrain Astronomy Society and their telescopes.

MID-STATES CONVENTION

The Mid-States Region of the Astronomical League will hold its annual meeting at the University of Tulsa, Tulsa, Oklahoma, June 20-21. The host is the Astronomy Club of Tulsa. Chairman for the convention is Roger C. Fletcher, 2317 S. Marion, Tulsa 14, Okla.

NORTH CAROLINA AMATEUR DIES

F. B. Eason, of Wilson, North Carolina, for many years a regional director for the American Meteor Society, passed away last November 8th. Mr. Eason was active in collecting observations of fireballs from which their paths through the atmosphere and their orbits around the sun could be computed. He also encouraged amateurs in the South to participate in meteoric astronomy.

STATE COLLEGE, PENNSYLVANIA

A dozen persons are members of the Nittany Valley Amateur Astronomers. The secretary is Mrs. Philip B. Lovett, 626 W. Nittany Ave., State College, Pa.

VALPARAISO, INDIANA

Originally started by students of the university, the Valparaiso University Astronomical Society welcomes any interested person to membership, regardless of age. Dr. D. L. Shirer of the physics department is the faculty advisor.

The club recently began grinding the mirror for a 6-inch telescope. The corresponding secretary is George G. Arnold, Box 276, Valparaiso University, Valparaiso, Ind.

BURBANK, CALIFORNIA

There are 17 members in the Burbank Astronomical Society. Dennis Rhoades, 823 Irving Dr., Burbank, Calif., is the secretary.

PONTCHARTRAIN, LOUISIANA

Last January, 26 amateurs organized the Pontchartrain Astronomy Society. During each month they meet on the first Friday for a lecture and at least once for observing. In addition to the senior membership, there are 20 juniors.

Officers are: Mrs. Faith Lee, 1511 Mandolin, New Orleans 22, La., president; J. W. Northrup, III, vice-president; Fred Overmier, secretary; and B. L. Hill, Jr., treasurer.

THIS MONTH'S MEETINGS

Baltimore, Md.: Baltimore Astronomical Society, 8 p.m., Enoch Pratt Library. April 20, Dr. Herbert Friedman, Naval Research Laboratory, "Rocket Observations of the October 12, 1958, Eclipse."

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. April 3, Drs. Geoffrey R. and E. Margaret Burbidge, Yerkes Observatory, "The Evolution of the Chemical Elements."

Edinburg, Tex.: Magic Valley Astronomical Society, 8 p.m., science building, Pan American College. April 24, Prof. Paul R. Engle, Pan American College, "Amateur Telescope Making."

Lemont, Ill.: Argonne Astronomy Club, 8 p.m., chemistry building, Argonne National Laboratory. April 22, William B. Doe, Argonne National Laboratory, "Astronomical Photography and Photometry."

Madison, Wis.: Madison Astronomical Society, 8 p.m., University of Wisconsin Planetarium. April 8, Dr. C. M. Huffer, Washburn Observatory, demonstration of the University of Wisconsin Planetarium.

Marietta, Ohio: Marietta Astronomical Society, 7:30 p.m., home of Miss Lillian E. Cisler, Cisler Terrace. April 29, Prof. Winston Love, Marietta College, "Our Expanding Knowledge of the Universe."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. April 1, Walter J. Semerau, Union Carbide Corp., "Construction and Use of Solar Observing Equipment for the Amateur."

New York, N. Y.: Junior Astronomy Club, 2 p.m., main building, New York University. April 18, Philip Seldon, "Moonwatch."

Philadelphia, Pa.: Rittenhouse Astronomical Society, 8 p.m., Franklin Institute. April 1, Dr. Bengt Strömgren, Princeton Institute for Advanced Studies, "The Youngest and Oldest Stars of Our Galaxy."

QUINCY, MASSACHUSETTS

Since January, the 45 members of the South Shore Astronomical Society have been meeting at 8 p.m. on the third Tuesday of each month in the Quincy YMCA. Within the club are two subgroups, for telescope making and astronomy study. An astrophotography section is planned.

Interested persons should communicate with the corresponding secretary, Mrs. Walter C. Paulding, 53 Walker St., N. Quincy 71, Mass., for more information.

MIDDLE EAST CONVENTION

The 1959 convention of the Middle East Region of the Astronomical League will be held at the du Pont Country Club, Wilmington, Del., on Saturday, May 9th. The host is the Delaware Astronomical Society. The registration fee of $1.00 may be sent now to Emil J. Volcheck, Jr., 1301 Orange St., Wilmington 1, Del.

HERE AND THERE WITH AMATEURS

Most of these societies hold regular meetings once or twice monthly, at which interested persons are always welcome. Details of each society's program can be obtained from the official whose name and address are given here.

*Members receive *Sky and Telescope* as a privilege of membership.
†Member organization of the Astronomical League.
‡Member organization of the Western Amateur Astronomers.
°Society has junior section.
||Independent junior society.

ALABAMA

BIRMINGHAM
Shades Valley Astronomy Club *†
G. Morgan, 1608 Barry Ave. (9). TR 9-8405
FLORENCE
Tri-Cities Astronomy Club *
R. May, 606 River Bluff Dr., Sheffield. EV 3-7845
HUNTSVILLE
Rocket City Astronomical Ass'n. *†
G. A. Ferrell, 621 Franklin St. JE 4-4809

ARIZONA

PHOENIX
Phoenix Observatory Ass'n. *‡
A. H. Hoff, Phoenix College. AM 6-4441
TUCSON
Tucson Amateur Astronomers *†‡
D. Strittmatter, 1840 E. Lee St. EA 5-9453

ARKANSAS

LITTLE ROCK
Arkansas Amateur Astronomy Club *†
C. P. Kulp, 1322 Donaghey Bldg.

CALIFORNIA

BAKERSFIELD
Kern Astronomical Society, Inc.
R. Stephens, 1230 Washington Ave., Oildale. EX 9-6587
BURBANK
Burbank Astronomical Society
D. Rhoades, 823 Irving Dr. TH 8-5880
CHINA LAKE
China Lake Astronomical Society *
J. R. Deal, 102-B Lauritsen. 5-0111, ext. 72626
EUREKA
Astronomers of Humboldt *
W. N. Abbay, Jr., 1745 Margaret Lane, Arcata. VA 2-4403
FRESNO
Central Valley Astronomers *‡
G. Reavis, 626 W. Lamona. AM 4-9771
LAGUNA BEACH
Laguna Beach Astronomy Club
Miss E. Phillips, 370 Anita St.
LONG BEACH
Excelsior Telescope Club *†‡
T. R. Cave, Jr., 265 Roswell Ave. HE 4-2263
LOS ANGELES
Los Angeles Astronomical Society, Inc. ‡
Miss L. Carlson, 3047 Vista St., Long Beach.
OAKLAND
Eastbay Astronomical Society, Inc. *‡
Miss P. Metz, 4827 Brookdale Ave. (19). KE 6-2074
OROVILLE
Feather River Astronomy Club
J. T. Jensen, Rte. 4, Box 1732. LE 3-0471
PALO ALTO
Peninsula Astronomical Society *‡
Miss A. Alksne, 4115 Amaranta Ave. DA 2-4406
PASADENA
Ass'n. of Amateur Astronomers ‡
E. Sloman, 1100 Armada Dr.
PLEASANT HILL
Mount Diablo Astronomical Society *
D. F. Charles, 868 Audrey Court.
RED BLUFF
Mt. Lassen Amateurs
F. Wyburn, Box 502. LA 7-4689
REDLANDS
Redlands Astronomical Society *
Mrs. E. Patterson, 2698 Fremontia Dr., San Bernardino. 83-7238
RIVERSIDE
Riverside Astronomical Club *
B. F. Jones, 5551 Magnolia Ave. OV 3-1854
SACRAMENTO
Sacramento Valley Astronomical Society *‡
Mrs. H. Smith, 1608 48th St. (19). GL 1-1483
SAN FRANCISCO
San Francisco Amateur Astronomers *‡
Randall Jr. Mus., 16th St. and Roosevelt Way.
SAN JOSE
San Jose Amateur Astronomers *‡
W. W. Phelps, 21090 Hazelbrook Dr., Cupertino. CH 3-1649
SAN RAFAEL
Marin Astronomical Society *‡
J. P. Treleven, Box 102, Fairfax.
SANTA ANA
Orange County Amateur Astronomers *
D. Miller, 12601 Glen St., Garden Grove.
SANTA BARBARA
Santa Barbara Star Cluster ‡
Capt. C. Adair, 607 Miramonte Dr. 2-1717
STOCKTON
Stockton Astronomical Society *‡
T. Pullum, 2076 W. Inman St. (4).
WHITTIER
Whittier Amateur Astronomers *‡
R. Young, Box 531. OX 3-0320
Whittier Astronomical Society *†
R. N. Sturtridge, 8416 Davista Dr.

COLORADO

BOULDER
Boulder Astronomical Society *†
H. H. Howe, 2419 Pennsylvania Ave.
COLORADO SPRINGS
Colorado Springs Astronomical Society *†
R. C. Moore, 2427 Paseo Rd. ME 3-7181
DENVER
Denver Astronomical Society *†‡°
E. H. Bronstein, 1747 S. Jasmine (22). SK 6-3232
PUEBLO
Pueblo Astronomical Society *†‡
Mrs. M. Struthers, 2329 E. Routt Ave. LI 3-1833
Pueblo Junior Astronomical Society †||
H. Niethammer, 839 Van Buren. LI 4-2819

CONNECTICUT

GREENWICH
Scanners' Club ||
G. Shea, 102 Milbank Ave. TO 9-4474
HARTFORD
Central Connecticut Amateur Astronomers *†
W. Fellows, R.F.D. 1, Hebron Ave., Glastonbury. ME 3-1871
NEW HAVEN
New Haven Astronomical Society, Inc. †
Mrs. J. Plato, 427 Ridgeview Rd., Orange. SY 9-2524
NEW LONDON
Thames Amateur Astronomical Society *†
Mrs. R. W. Tumicki, R.F.D. 1, Box 497, Uncasville. TI 4-8336
NEWTON
Western Connecticut Astronomical Society *
Dr. W. Green, Box W.
STAMFORD
Fairfield County Astronomical Society *†°
D. Mitchell, Cliffdale Rd., Greenwich. TO 9-1684
STRATFORD
Boothe Memorial Astronomical Society, Inc. *†
B. W. Reilly, Box 2272, Noble Sta., Bridgeport (8). ED 6-9287
WINDSOR LOCKS
Burgington Astronomical Society ||
D. McLeod, 37 Center St. NA 3-3622
WINSTED
Litchfield Hills Amateur Astronomy Club
J. Zimmerman, Rte. 20, Box 5, W. Hartland. FR 9-3157

DELAWARE

WILMINGTON
Delaware Astronomical Society *†
1301 Orange St. (1). OL 6-8364

DISTRICT OF COLUMBIA

WASHINGTON
Maret Astronomers Club *||
P. Moretti, 3435 Yuma St. N.W. (8).
National Capital Astronomers *†°
Miss P. Seips, Box 271 (4).

FLORIDA

DAYTONA BEACH
Daytona Beach Star Gazers
W. T. Thomas, 105 N. Halifax. CL 2-8049
EAU GALLIE
Indian River Astronomical Society *†
C. P. McDarment, Box 55, Rte. 1.
EGLIN AIR FORCE BASE
Choctaw Astronomical Society *
R. M. Porter, Box 221, Shalimar. CH 4-5578
FT. LAUDERDALE
Ft. Lauderdale Astronomical Society †
Dr. F. Denniston, 915 N. E. 2nd St. JA 2-5224
JACKSONVILLE
Jacksonville Amateur Astronomers Club *†°
E. L. Rowland, Jr., 225 W. Ashley St. EL 4-8597
KEY BISCAYNE
Key Biscayne Astronomical Ass'n. ||
T. Ferris, 365 Pacific Rd. EM 1-5524
KEY WEST
Key West Astronomy Club *†
Miss M. W. Turner, 95 Sigsbee Rd., Box 915. 6-9803
MIAMI
Gulfstream Astronomical Ass'n., Inc. *†
Mrs. G. Lobdell, 3169 New York St., Coconut Grove. HI 8-4288
Southern Cross Astronomical Society, Inc. *†
A. P. Smith, Jr., 1601 S.W. 10th St. FR 4-7145
ORLANDO
Amateur Astronomy Club of Orlando *
Dr. T. E. Gordon, 1410 Westmoreland Dr. GA 2-8226
ROCKLEDGE
Astronomy Club of Rockledge ||
P. D. Butler, Box 229. NE 6-7217

ST. PETERSBURG
St. Petersburg Astronomy Club *†
Mrs. D. Martin, 3761 5th Ave. N. (13).
TAMPA
Tampa Amateur Astronomical Society *†
E. Z. Randall, 407 W. Chelsea St. 33-6391
WEST PALM BEACH
Astronomers Club of the Palm Beaches †
Mrs. D. D. Sinclair, Box 1108. JU 2-6830

GEORGIA

ATLANTA
Atlanta Astronomy Club *†°
W. H. Close, 225 Forkner Dr., Decatur. DR 3-3945
HARTWELL
Hartwell Astronomy Club †||
E. Heaton, Rte. 3.
MACON
Macon Amateur Astronomers Club *†
P. E. Haines, 505 Eldorado Dr. 5-5084

HAWAII

HONOLULU
Hawaiian Astronomical Society *
E. G. Linsley, B. P. Bishop Museum (17).

IDAHO

BOISE
Boise Astronomical Ass'n.
Miss L. Moulton, 1712 N. 28th.
IDAHO FALLS
Idaho Falls Astronomical Society *
Mrs. O. D. Hendrickson, 475 J St. JA 2-3474
TWIN FALLS
Southern Idaho Amateur Astronomers
N. Herrett, 1220 Kimberly Rd. RE 3-0868

ILLINOIS

CHICAGO
Chicago Astronomical Society *
A. A. Hay, 8024 W. Winnemac Ave. (31).
Chicago Junior Astronomical Society *†||
E. Zimmermann, 133 Franklin Ave., River Forest. FO 9-8186
Lincoln Park Astronomical Society ||
D. Fretland, 509 W. Deming Pl. (14).
DANVILLE
Danville Astronomical Society †||
D. D. Morrison, 5 E. Fairchild.
GALESBURG
Galesburg Amateur Astronomers *†
H. L. Horein, 1246 N. Morton Ave. DI 2-0873
GENEVA
Fox Valley Astronomical Society *
J. Zoda, 420 Fellows St., St. Charles. 5507
KANKAKEE
Kankakee Junior Astronomers *||
D. Soucie, 235 S. Gordon. WE 3-6574
LEMONT
Argonne Astronomy Club *†
H. DaBoll, Box 299, Argonne Nat'l. Lab. 800, ext. 2711
LOMBARD
Tree Towns Astronomy Club †||
R. Henson, 26 S. Westmore Ave.
MOLINE
Popular Astronomy Club *†
H. J. Schieck, 3303 Coaltown Rd.
OAK PARK
Sirius Astronomical Society †||
Miss C. Resnick, 722 N. Lombard Ave. EU 6-4742
PEORIA
Astronomy Section, Academy of Science *
R. Van Zandt, 1100 N. Parkside Dr. 4-5621
ROCKFORD
Rockford Astronomical Society *||
W. Fonvielle, 528 Howard Ave. 8-5969
THORNTON TOWNSHIP
South Suburban Astronomical Society *||
L. Aubrecht, 16128 S. Drexel, S. Holland.

INDIANA

EVANSVILLE
Evansville Astronomical Society *†
Dr. R. T. Dufford, 512 S. Weinbach Ave. (14). GR 6-7856
FT. WAYNE
Ft. Wayne Astronomical Society *
Mrs. M. Wininger, R.R. 4, Hillegas Rd. T-8487
INDIANAPOLIS
Indiana Astronomical Society *†°
W. E. Wilkins, 6124 Dewey Ave. FL 7-5946
KOKOMO
Kokomo Astronomical Society *
P. Miles, Box 645. GL 2-9378
MADISON
Madison Junior Astronomy Society *†||
T. A. Winkel, 607 N. East St.
SOUTH BEND
St. Joseph Valley Astronomical Society
R. Bargmeyer, 59597 S. Ironwood Rd. (14). AT 9-1963
VALPARAISO
Valparaiso Univ. Astronomical Society
G. Arnold, Box 276, Valparaiso Univ. 3-4163

IOWA

DES MOINES
Des Moines Div., Great Plains Astronomical Soc. *
R. T. Morehead, R.R. 1, Beaver Ave.
DUBUQUE
Dubuque Astronomical Society *
H. W. Klauer, 1795 Adair. 2-6762
FT. DODGE
Ft. Dodge Astronomy Club
W. W. Van Gundy, 1210 1st Ave. N. 3-2503
MARSHALLTOWN
Central Iowa Astronomers *
J. C. Steffa, 404 E. Church St. 2-1264
WATERLOO
Northeast Iowa Div., Great Plains Ast. Soc. *†
Dr. H. L. Sisson, 405 E. Dale St.

KANSAS

TOPEKA
Topeka Astronomical Society
F. Pilcher, 803 Lindenwood St.
WICHITA
Wichita Astronomical Society *†
S. Whitehead, 425 N. Lorraine (8). MU 2-6642

KENTUCKY

LEXINGTON
Bluegrass Astronomical Society *†
J. C. Hayden, 336 Colony Rd. 6-7657
LOUISVILLE
Louisville Astronomical Society *†
Mrs. V. C. Lipphard, 2421 Calvin (6). TW 6-9084
Louisville Junior Astronomical Society *†||
D. Kleinman, 1414 Goddard (4). HI 1365-J

LOUISIANA

GRETNA
Gretna Astronomical Society
J. A. Gunther, 209 Newton St. FO 1-0034
LAKE CHARLES
Lake Charles Amateur Astronomers Club †
C. Fronczek, Rte. 1, Box 51, Westlake. HE 6-1797
METAIRIE
New Orleans Soc. for Advancement of Astronomy
J. Mickel, 1307 Ridgelake Dr. VE 3-8224
NEW ORLEANS
New Orleans Amateur Astronomers Ass'n. *†
W. E. Wulf, 2107 Annunciation St. (13). JA 5-0706
OPELOUSAS
Opelousas Amateur Astronomers Ass'n.
Dr. W. G. Owen, IV, 311 E. Tennis St. 3812
PONTCHARTRAIN
Pontchartrain Astronomy Society *
Mrs. F. Lee, 1511 Mandolin, Apt. C, New Orleans (22).

MARYLAND

BALTIMORE
Baltimore Astronomical Society *†
Maryland Academy of Sciences, Pratt Libr. Bldg., 400 Cathedral St. (1). MU 5-2370

MASSACHUSETTS

CAMBRIDGE
Amateur Telescope Makers of Boston *†
W. R. Battersby, 14 Munroe Rd., Lexington. VO 2-2565
Bond Astronomical Club *†
R. C. Smith, 519 Morrissey Blvd., N. Quincy (71). GR 2-1938
NEW BEDFORD
Amateur Astronomy Club of New Bedford ||
R. Pastie, 12 Fielding St. WY 4-5610
PALMER
Pioneer Valley Astronomy Club †
E. A. Reynolds, 47 High St., Thorndike. 524-W
QUINCY
South Shore Astronomical Society
Mrs. W. C. Paulding, 53 Walker St., N. Quincy (71). PR 3-5513
SPRINGFIELD
Springfield Stars Club *†°
J. E. Welch, 107 Lower Beverly Hills, W. Springfield. RE 4-9179
WEST HARWICH
Cape Cod Astronomy Club *
C. Perisho.
WORCESTER
Aldrich Astronomical Society *†
T. L. Agos, 1 W. Boylston Terr.

MICHIGAN

BATTLE CREEK
Battle Creek Amateur Astronomy Club †
Mrs. W. V. Eichenlaub, 47 Everett Ave. 2-3059
DETROIT
Detroit Astronomical Society, Inc. *†
B. L. Reber, 22131 Ulster (19). KE 7-4197
FLINT
Flint Astronomy Club *†
Mrs. M. Klarich, 3520 Gloucester (3). CE 8-4579
GRAND RAPIDS
Grand Rapids Amateur Astronomical Ass'n. *†
D. Thompson, 551 Fountain St. N.E.
Grand Rapids Junior Astronomical Society ||
B. Hymes, 1500 Seminole Rd. S.E. CH 1-1460
JACKSON
Jackson Astronomical Society *
J. T. Barnes, 6851 Ann Arbor Rd. ST 4-5244
KALAMAZOO
Kalamazoo Amateur Astronomical Ass'n. †
Mrs. V. Shellman, 3809 Allendale. FI 4-8295
LANSING
Lansing Amateur Astronomers *†
R. C. Elliott, 434 Cowley Ave., E. Lansing. ED 2-5241
PONTIAC
Pontiac-Northwest Detroit Astronomers Ass'n. *†
G. Carhart, 40 Hadsell Dr. FE 2-9980
SAGINAW
Saginaw Valley Astronomical Ass'n. *†
A. Trollman, 805 S. Warner St., Bay City.
STURGIS
Sturgis Astronomy Group *
Mrs. S. Butler, 805½ E. Main St. 464-J

MINNESOTA

EDINA
Edina Astronomy Club *†
H. Wiltz, 5732 Chowen Ave. S., Minneapolis (10).

MINNEAPOLIS
Minneapolis Astronomy Club †
Mrs. M. B. Haarstick, Science Mus., Pub. Libr. FE 8-0781
Minneapolis Junior Astronomy Club *||
Mrs. M. B. Haarstick, Science Mus., Pub. Libr.
ST. PAUL
St. Paul Telescope Club *†
F. F. Miller, 1212 7th Ave. S., S. St. Paul. GL 5-5934

MISSISSIPPI

LAUREL
Laurel Sky Club *
H. H. Dyke, 11 Country Club Dr. 6033

MISSOURI

FAYETTE
Central Missouri Amateur Astronomers *†
R. C. Maag, 820 S. Osage, Sedalia.
JOPLIN
Junior Astronomers League ||
D. Owen, 1720 Murphy Blvd.
KANSAS CITY
Astronomy Club of Kansas City *†
Mrs. L. Kinsey, 1522 Brush Creek. WA 3-3410
ST. LOUIS
St. Louis Astronomical Society *†
Mrs. N. Fallert, 9804 Honeycut Lane (19). WO 1-8427

NEBRASKA

OMAHA
Omaha Div., Great Plains Astronomical Soc.
R. Osborn, 2035 N. 53 St. GL 5431

NEVADA

LAS VEGAS
Astronomical Society of Southern Nevada *
T. Constanten, 1650 Michael Way. DU 2-9604
Unistars
N. Carter, 2208 Hoyt Ave. DU 2-3068
RENO
Astronomical Society of Nevada ‡
A. A. Garroway, 2040 Meadow View Lane. FA 3-0696

NEW HAMPSHIRE

KEENE
Keene Amateur Astronomers †
R. A. Hebert, 12 Holt Pl. EL 2-6601
MANCHESTER
Manchester Astronomical Society *
R. E. Durette, 8 Keene St., Bedford. NA 5-8167
NASHUA
Merrimack Valley Astronomical Society *†
A. J. Barrett, R.F.D. 2, Reeds Ferry. HA 4-3243
NEWMARKET
Great Bay Amateur Astronomers *
Miss A. Geoffrion, Packers Falls Rd.

NEW JERSEY

CALDWELL
West Essex Astronomical Society
R. M. Greenley, 412 Bloomfield Ave. CA 6-6751
FT. MONMOUTH
Society of Telescopy, Astronomy and Radio *
Miss A. Stommel, Box 127, Rumson.
JERSEY CITY
Gregory Mem. Obs. of Paul Revere Boys Club †||
P. J. Kocmalski, 339 Wayne St. (3).
PATERSON
North Jersey Astronomical Society
D. Trombino, 4-4D Alabama Ave. (3).
ROSELLE PARK
Amateur Astronomers of Union County *†
K. D. Smith, 871 Dorian Rd., Westfield.
RUTHERFORD
Astronomical Society of Rutherford
Mrs. A. Cox, 478 Riverside Terr. WE 9-0453
TEANECK
Bergen County Astronomical Society †
C. V. Lee, 1308 Hudson Rd., W. Englewood. TE 6-1525
UNION CITY
Hudson County Astronomical League
S. Giardina, 631 13th St.
UPPER MONTCLAIR
Montclair Telescope Club *
R. Boegehold, 280 N. Mountain Ave.

NEW MEXICO

LAS CRUCES
Astronomical Society of Las Cruces *†‡°
J. E. Durrenberger, Box 625. JA 6-2968
ROSWELL
Pecos Valley Sky and Telescope Club *
Dr. R. R. Boice, Rte. 2, Box 163-A. MA 2-7171

NEW YORK

ALBANY
Albany Amateur Astronomers *†
Mrs. H. R. Bain, Murray Dr., Glenmont.
BABYLON
Long Island Observers' Ass'n. *
J. A. Tosto, 8 Bacon Lane. MO 9-9173
BETHPAGE
Grumman Astronomical Society *
R. T. Inman, 10 Radcliff Lane, S. Farmingdale. CH 9-8107
BINGHAMTON
Astronomical Society of Broome County
Dr. H. Nitka, 46 Matthews St.
BUFFALO
Buffalo Astronomical Ass'n. *†
G. N. Rote, 575 Elmwood Ave., Apt. 8.
CORNING
Corning Astronomy Club *
Mrs. E. Johnston, 106 Jennings St. 2-5142
JAMESTOWN
Astronomers Guild of Jamestown *
B. Hanson, 613 Stowe St. 92-811
NANUET
Rockland Astronomical Society
Miss A. Mowat, 57 S. Nauraushaun Rd., Pearl River.
NEW YORK
Amateur Astronomers Ass'n., Inc. *
Mrs. A. Pridmore, 201 W. 79th St., Room 1010 (24). EN 2-7100
Junior Astronomy Club †||
New York Univ., 100 Washington Sq. E. (3).
ROCHESTER
Astronomy Section, Academy of Science †
W. W. Whyman, 193 Oak St., Batavia. FI 3-1899
SCHENECTADY
Schenectady Astronomy Club *†°
C. E. Johnson, 102 State St. DI 6-9522
SYRACUSE
Syracuse Astronomical Society *†
C. D. Fuller, 130 Falls Blvd., Chittenango. NE 7-3395
TROY
Rensselaer Astrophysical Society *†
Dr. R. Fleischer, Rensselaer Polytechnic Inst.
Troy Astronomy Club †
D. Harris, 1032 19th St., Watervliet.
UTICA
Utica Amateur Astronomers *†
W. Burak, Sr., 1663 Lincoln Ave.
WANTAGH
Long Island Astronomical Society
R. E. Franklin, 174 Jayne Ave., Patchogue.
YONKERS
Hudson River Museum Astronomy Club °
J. A. Yules, 616 E. Lincoln Ave., Mt. Vernon. MO 8-0828

NORTH CAROLINA

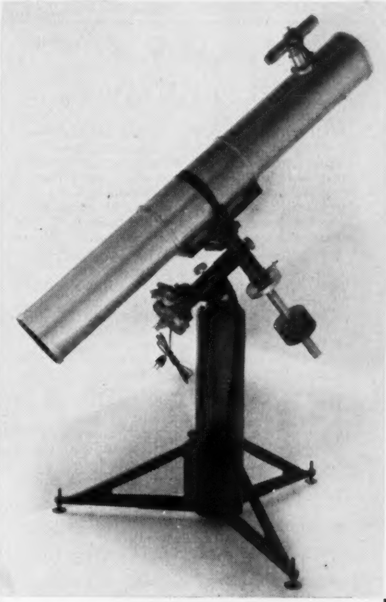
CHAPEL HILL
Chapel Hill Astronomy Club *†
Miss M. I. Perry, 9 Maxwell Rd. 9-6334
CHARLOTTE
Charlotte Amateur Astronomers Club *†
Mrs. P. Nowlin, 946 Bromley Rd.
GREENSBORO
Greensboro Astronomy Club *†
Dr. F. R. Crownfield, Guilford Coll. 2456
WINSTON-SALEM
Forsyth Astronomical Society *†
K. A. Shepherd, 903 West End Blvd. 2-1631

NORTH DAKOTA

GRAND FORKS
Red River Astronomy Club *
Miss M. Barlow, 704 Cottonwood St.

OHIO

AKRON
Astronomy Club of Akron *
Mrs. R. J. Couts, 878 Kennebec Ave. (5). ST 4-8450
BAY VILLAGE
Lake Erie Jr. Museum Junior Astronomers †||
Mrs. E. W. Fleming, 630 Canterbury Rd. TR 1-3742
CINCINNATI
Cincinnati Astronomical Ass'n. *
G. A. Lineback, 2933 Cortelyou Ave. JE 1-1442
Cincinnati Astronomical Society, Inc. *†
Mrs. D. H. Watson, 8822 De Soto Dr. (31). WE 1-5919
CLEVELAND
Cleveland Amateur Astronomers Club
J. B. Breckinridge, Mus. of Nat. Hist. Planetarium, 10600 East Blvd. (6). SW 1-7966
Cleveland Amateur Telescope Makers
Museum of Natural History, 10600 East Blvd. (6).
Cleveland Astronomical Society
Mrs. H. M. Strohm, Warner and Swasey Obs., Taylor Rd., E. Cleveland (12). GL 1-5625
COLUMBUS
Battelle Astronomy Club *
J. W. Kissel, Battelle Mem. Inst., 505 King Ave. AX 9-3191, ext. 363-2330
Columbus Astronomical Society *†
Mrs. J. Gann, 420 N. Cassady Rd. (9). CL 2-8421
DAYTON
Miami Valley Astronomical Society *†
F. E. Sutter, 5038 Far Hills Ave. (59). AX 3-1827
ELYRIA
Black River Astronomical Society *
G. Diedrich, 653 Weller Rd. 44-033
HILLSBORO
Hillsboro Astronomical Society *
Mrs. D. N. McBride, Box 85. 1169
LIMA
Lima Astronomy Club *†
Mrs. C. Hurless, 1742 Rise Ave.
MARIETTA
Marietta Astronomical Society °
Miss L. E. Cisler, Cisler Terr. FR 3-0231
MASSILLON
Massillon Astronomy Club *
R. Snavely, Rte. 1, Barrs Rd. TE 3-4087
NEWARK
Newark Astronomical Society
G. Cooperrider, 326 N. 11th St. FA 3-0452
TOLEDO
Toledo Astronomical Society
E. D. Edenburn, 4124 Commonwealth Ave. (12). CH 3-3558
WARREN
Mahoning Valley Astronomical Society *
Mrs. C. R. Prather, 1363 Drexel Ave. N. W. 4494-2
YOUNGSTOWN
Youngstown Astronomy Club *
W. F. Wright, Jr., 618 Aetna St., Salem.



OKLAHOMA

Oklahoma City
Astronomy Club of Oklahoma City *†
E. Breet, Aeronautical Ctr., Rm. 103, Will Rogers Field.
Tulsa
Astronomy Club of Tulsa *†
R. F. Reid, 1948 E. 14th St. WE 9-5286
Oklahoma Astronomical Society *†||
L. Dicken, 1332 S. Sandusky (12). MA 6-9644

OREGON

Eugene
Amateur Astronomy League of Eugene
R. Fidler, 1237 Ferry St.
Grants Pass
Rogue Valley Astronomers and ATM's
H. R. Dickey, 1587 E. Fruitdale Rd.
Portland
Amateur Telescope Makers and Observers †‡°
Miss V. Babin, 3038 N. E. 56th Ave. (13). AT 7-9405
Portland Astronomical Society *†
Mrs. M. Krutsinger, 6525 N. E. Davis (16). AL 4-1491
Salem
Salem Astronomical Society *
Mrs. B. W. Christensen, 1425 Marshall Dr.

PENNSYLVANIA

Allentown
Lehigh Valley Amateur Astronomical Soc.
Mrs. O. G. Lewis, E. Rock Rd.
Bristol
Polaris Astronomical Society *
Miss A. Kovach, 3524 Carnarvon Ave. ST 8-1892
Clearfield
Amateur Astronomers of Clearfield *
L. Gearhart, Jr., 114 S. 5th St. 5-5748
Harrisburg
Astronomical Society of Harrisburg *†
E. L. Naylor, 320 Wilhelm Rd. CE 2-6479
Millvale
Shaler Township Junior Amateur Astronomers ||
C. Raible, 200 Rebecca Sq. (9). TA 1-2171
Philadelphia
Amateur Astronomers of Franklin Inst. †
E. F. Bailey, Franklin Inst. (34). LO 4-3600
Rittenhouse Astronomical Society *†
J. W. Streeter, Franklin Inst. (34). LO 4-3600
Pittsburgh
Amateur Astronomers Ass'n. of Pittsburgh *†°
F. M. Garland, 127 Park Pl., McKnight Village (9).
Springdale
Allegheny Valley Amateur Astronomers *†°
W. E. Stocks, 215 Carson St. BR 4-8835
State College
Nittany Valley Amateur Astronomers
Mrs. P. B. Lovett, 626 W. Nittany Ave. AD 7-7019
Washington
Washington County Astronomy Club *
Mrs. L. Withrow, R.D., 1, Eightyfour. WI 1-7191
Waynesboro
Astronomical Society of Waynesboro *†
W. O'Toole, III, Box 302.
York
York Astronomical Society *†
J. N. Lewis, 157 Scarboro Dr. 8-1080

RHODE ISLAND

North Scituate
Skyscrapers, Inc.
G. Gregory, 585 Elmgrove Ave., Providence (6).

SOUTH CAROLINA

Hartsville
Hartsville Astronomical Society ||
B. Hopkins, Box 423. 1540

SOUTH DAKOTA

Rapid City
Rapid City Astronomical Society *
Dr. R. F. Heckman, S. D. State School of Mines and Technology.

TENNESSEE

Brentwood
Brentwood Astronomy Club ||
R. Vaughn, Valley View Rd.
Bristol
Bristol Amateur Astronomical Club *†
H. Snow, 618 Center Dr. SO 4-8959
Chattanooga
Barnard Astronomical Society *†
J. M. Sherlin, 1314 McBrien Rd. (11).
Kingsport
Kingsport Astronomical Society *
J. Brown, 1329 Belmeade Dr. CI 5-7513
Knoxville
Knoxville Astronomical Ass'n. °
D. L. Bowen, 2110 Fairmont Blvd. 2-1798
Memphis
Memphis Astronomical Society *†
S. P. Franklin, 5030 Lynbar. MU 3-9737
Nashville
Barnard Astronomical Society *
Miss P. H. Hudgens, Dyer Obs., Vanderbilt Univ.
Portland
Portland Astronomical Society †
R. O. Riggs, Box 42. 3781

TEXAS

Abilene
Abilene Astronomical Society *
R. B. Edmundson, 1849 N. 8th St. OR 4-5932
Austin
Forty Acres Astronomy Club *†
Box 7994, University Sta. (12).
Brownfield
Brownfield Astronomy Club *
C. Isbell, Rte. 1. 2074
Dallas
Texas Astronomical Society †°
E. M. Brewer, 5218 Morningside Ave. (6). TA 6-3894
Edinburg
Magic Valley Astronomical Society †
P. R. Engle, Pan American Coll. Obs. DU 3-1151
Ft. Worth
Ft. Worth Astronomical Society *†
R. M. Camp, Jr., 2826 Gordon.
Junior Astronomy Club of Children's Mus. †||
Miss C. M. Noble, 1511 Cooper St. (4). ED 2-9892
Houston
Houston Amateur Astronomy Club *
W. W. Myers, 7424 Tipps St. (23). WA 6-5947
Kilgore
East Texas Astronomical Society *†
T. H. Anderson, Jr., 601 Highland Dr.
Laredo
Laredo Astronomy Club *
S. Freidin, Box 1148. 3-8345
Midland
Midland Amateur Astronomical Society ||
Miss M. A. Price, 2106 W. Michigan. MU 4-4678
San Angelo
San Angelo Amateur Astronomers Club *
A. Clark, 1112 Algerita Dr. 2-1622
San Antonio
San Antonio Astronomy Club *†
M. Nocker, 750 Bailey Ave. (10). LE 4-5512

UTAH

Salt Lake City
Astronomical Society of Utah *
J. W. Geertsen, 4461 S. 9th East St. (17). AM 6-4602

VERMONT

Springfield
Springfield Telescope Makers †
C. R. Ranney, 3 Hillcrest Rd. TU 5-2436

VIRGINIA

Harrisonburg
Astral Society
M. T. Brackbill, Eastern Mennonite College.
Norfolk
Norfolk Astronomical Society *†°
A. D. Hustead, Weather Bur., Municipal Airport (13). LO 3-4368
Richmond
Richmond Amateur Junior Astronomers ||
Dr. E. Hoff, 117 Gaymont Rd. (26). 88-3368
Richmond Astronomical Society *†
B. Ragland, 601 E. Franklin St. (19). 2-3043
Roanoke
Amateur Astronomers of Roanoke *
W. B. Daniel, 2202 Richlieu Ave. S.W. 3-2637

WASHINGTON

Seattle
Seattle Amateur Astronomical Society *†°
N. C. Dalke, 8017 Stroud Ave. (3). PL 7498
Spokane
Amateur Telescope Makers of Spokane *†
P. Spendlove, W. 2422 Upton Ave. (13).
Tacoma
Tacoma Amateur Astronomers †
Mrs. R. H. Atkinson, 2816 N. Union Ave. (7). PR 1492
Wenatchee
North Central Washington Astronomical Soc. *†
H. C. Kirkpatrick, Rte. 4, Box 4100. 2-2131
Yakima
Yakima Amateur Astronomers *†
E. J. Newman, 324 W. Yakima Ave. GL 2-9825

WEST VIRGINIA

Fairmont
Fairmont Amateur Astronomers Ass'n., Inc. †
D. Brown, 1255 Fennimore St. 629
Vienna
Vienna Astronomical Society
W. T. Dixon, 3501 10th Ave. AX 5-4708
Wheeling
Oglebay Inst. Astronomical Ass'n.
R. W. Schramm, Speidel Obs. WO 2125

WISCONSIN

Beloit
Beloit Astronomical Society *†
Dr. K. E. Patterson, 304 Public Service Bldg. EM 5-7662
Madison
Madison Astronomical Society †°
Dr. C. M. Huffer, Washburn Obs., Univ. of Wisconsin. AL 5-3311, ext. 2551
Milwaukee
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OBSERVER'S PAGE

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The Variable Star U Coronae Borealis

Well placed for observation in the spring sky, the eclipsing variable star U Coronae Borealis is easily located about midway between Delta Bootis and Eta Coronae Borealis. Its 1950 co-ordinates are $15^h\ 16^m.2$, $+31°\ 50'$. It is in the same finder field as the well-known long-period variable S Coronae Borealis, and is readily identified with the aid of the AAVSO chart, reproduced here, for the latter star.

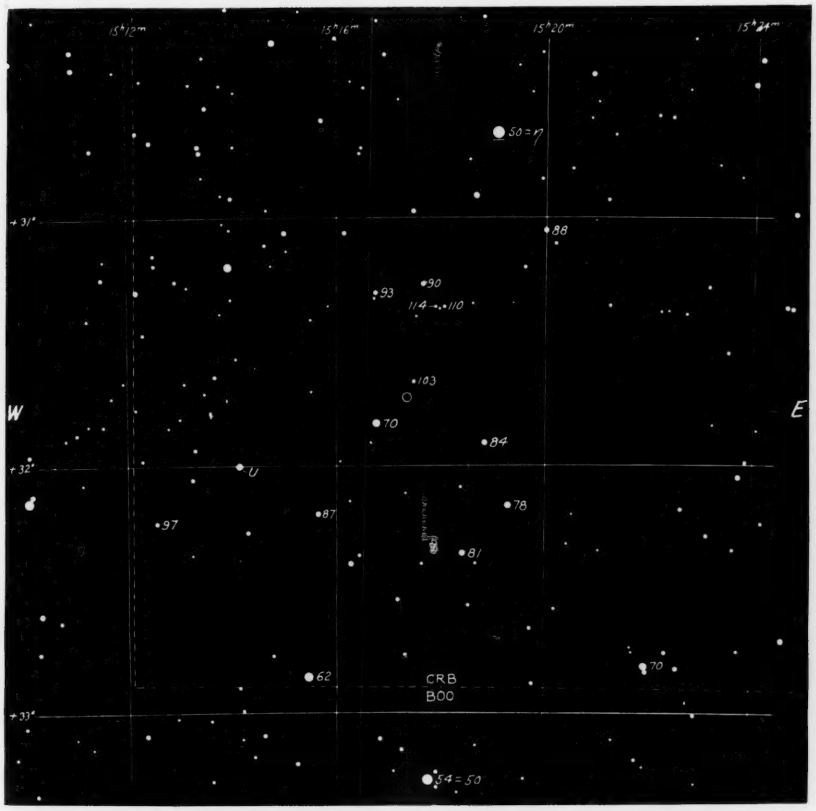
U Coronae Borealis is of the Algol type. Normally of about magnitude 7.6, it fades to about 8.8 at regular intervals of 3.4522 days. These eclipses each last approximately 10 hours, but during the middle 1½ hours there is little brightness change. The best times to watch are the two hours just before or just after this nearly constant phase, when the light of U CrB is changing most rapidly.

Recently this variable has attracted much attention because of a marked shortening in its period. Determinations of times of minimum are urgently needed, as has been pointed out by the Polish astronomer E. Rybka. Since the star is bright enough to be easily observed with a 3-inch telescope, amateur astronomers can make a most valuable contribution.

The observations desired consist of careful estimates of brightness, made at intervals of 20 minutes or so during nights when the variable passes through minimum. On the chart, comparison star brightnesses are provided to the nearest 0.1 magnitude (the decimal points being omitted to avoid confusion with star symbols). By careful interpolation of the variable between two comparison stars, one brighter and one fainter than U CrB, the magnitude of the latter is obtained to tenths. The time of each such observation should be recorded to within a minute or two.

On any one night, it is very desirable that estimates be made on both the falling and the rising portions of the light curve. If possible, several minima should be observed in this way. Amateurs who participate in this work are asked to send a copy of their observing record for analysis to Sky and Telescope, Harvard Observatory, Cambridge 38, Mass.

The following approximate predictions of coming minima of U CrB have been taken from *International Supplement* No. 30 of Krakow Observatory. They are



This chart is used by members of the American Association of Variable Star Observers to study the star S Coronae Borealis, marked by the open circle at the center. U Coronae Borealis lies below and to the left, directly on the +32° circle of declination. The chart co-ordinates are for 1900.

given in Universal time; to obtain Eastern standard time, subtract five hours; Central standard time, six hours; and so on.

April 1, 19^h; 5, 6^h; 8, 17^h; 12, 3^h; 15, 14^h; 19, 1^h; 22, 12^h; 25, 23^h; 29, 10^h.

May 2, 20^h; 6, 7^h; 9, 18^h; 13, 5^h; 16, 16^h; 20, 3^h; 23, 14^h; 27, 0^h; 30, 11^h.

DEEP-SKY WONDERS

IF WE DIVIDE the starry sphere into 24 lunes, like sections of an orange, each one hour of right ascension wide, we find that the Messier objects are evenly enough spread so that only two of these lunes have none. The strips starting at 4^h and at 22^h are vacant; by contrast, the 12^h strip has 20 Messier objects, followed by 18^h with 15, and 5^h and 17^h are tied with eight each. Thus the amateur always has some of these famous deep-sky wonders to view, even from a backyard with limited access to the sky.

The 11^h strip, which in April coincides with the meridian in early evening, has five of Messier's objects – though only one, the Owl nebula, is well known to the average amateur. In the north, just under the bowl of the Big Dipper, lie M97 (the Owl), M108, and M109; in the south, beneath the triangle of Leo, are the twin spirals M65 and M66. These five can give a 3-inch telescope or a big pair of binoculars an exciting evening's workout.

The Owl, also known as NGC 3587, lies southeast of Beta Ursae Majoris, at right ascension 11^h $12^m.0$, declination $+55°$ 18′ (1950 co-ordinates). It is a big, vague planetary nebula, 3′ in diameter and of magnitude 11 – easy in 65-mm. binoculars. Barnes, in his *1001 Celestial Wonders* (1927, out of print), calls this object dull toned, but memorable. William Herschel long ago thought it was a cluster of stars, unresolvable because of its immense distance. Even though today we know of planetaries three times farther, this object's distance of about 10,000 light-years will make many share Herschel's feeling of its remoteness.

Strangely enough, Admiral W. H. Smyth could see nothing but a pale, uniform disk "about the size of Jupiter," yet a 6-inch today will show something of the two dark holes in M97. But Smyth wrote before the Earl of Rosse found them, indicating that it is much more difficult to discover something than to confirm it. My 10-inch, under clear Kansas skies, shows the full 3′ diameter of the Owl.

About halfway between M97 and Beta is M108 (NGC 5457), at 11^h $08^m.7$, $+55°$ 57′. It is a bright strip of a spiral nebula, 8′ by 2′ in extent, of magnitude 10, with a faint foreground star superimposed. Herschel listed it as No. 46 of his class V (very large nebulae), and therefore Norton's *Star Atlas* marks it as 46^5. It is easily seen in 50-mm. binoculars. Across the bowl of the Dipper and just south of Gamma lies M109 (NGC 3992), the last of the objects assigned a Messier number. It is a medium-bright (11th-magnitude) spiral galaxy, 7′ in extent, located at 11^h $55^m.0$, $+53°$ 39′. M109 is labeled 45^5 in Norton's.

In Leo, M65 (NGC 3623) is at 11^h $16^m.3$, $+13°$ 23′, with M66 (NGC 3627) not far from it. Barnes called this appearance "very curious and mystifying," and Rev. T. W. Webb noted long ago that the elongations of these objects are in different directions. In my 10-inch reflector they lie in the same field, quite bright and rather featureless.

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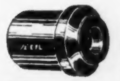

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7 x 50	372	"Zeiss"	24.95	22.50
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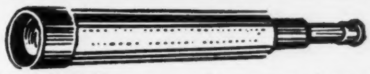

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A. JAEGERS

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Observing the Moon — Davy Y

NEAR the western edge of Mare Nubium are two relatively inconspicuous craters, Davy and Palisa. Neither of these offers much to the lunar student, except for several craterlets in Palisa, and a scattered group of low hills in Davy. Our primary interest, however, is not in the craters but in the remarkable feature lying between them.

This curious formation, known as Davy Y, is a walled plain with an obviously rectangular outline. Few lunar walled plains are truly circular, most of them being more or less polygonal in shape, but nowhere on the lunar surface, with the possible exception of some indefinite structures near the north polar regions, is there any counterpart of Davy Y.

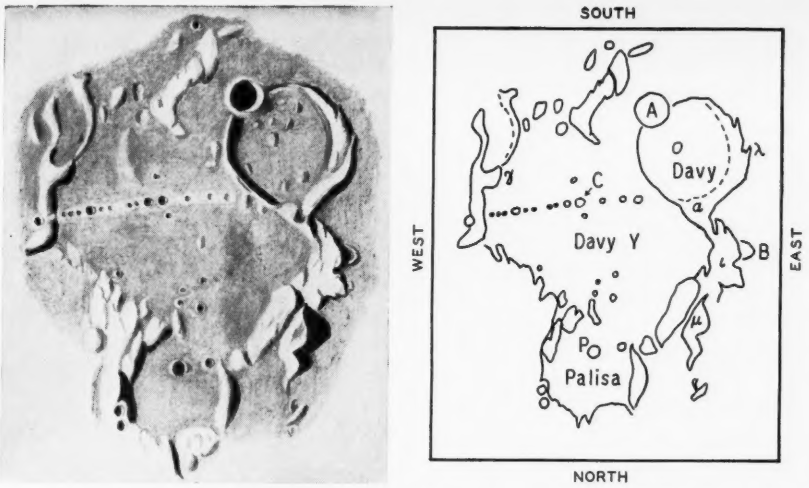
Its low walls are generally in a ruined condition. Beginning at the northeast corner, where there is a wide pass into Palisa, and then proceeding eastward, the wall is fairly uniform and consists of a well-developed series of ridges. Passing Davy, to its southwest we find some broad gaps in the wall. Along the southern perimeter to as far as the western corner of the rectangle, the broken ridges are low and curved, as if they were remnants of small craters that once existed there.

Probably the highest portion of Davy Y is its western wall, which is a continuation of the highlands to the west. The abruptness of the scarp (Davy γ) may indicate that a considerable subsidence of the floor of Davy Y occurred during its early history.

Like other walled plains, this one contains much fine detail in its interior – small craterlets, low ridges, and hills – requiring good observing conditions to be well seen. The most curious feature is the chain of small craterlets, extending through a narrow pass in the western rampart and across the floor as far as the rim of Davy. I have counted 14 craterlets in this chain, including the shallow saucerlike depressions at the eastern end.

Both W. Goodacre and H. P. Wilkins have described this feature as a crater-cleft, but in my many observations I have yet to see this cleftlike aspect – the craterlets are spaced across the plain seemingly without being connected by a narrow valley. Nevertheless, these little craters may be evidence for tertiary volcanic activity along a line of weakness in the lunar crust; it is difficult to believe they could have had a meteoritic origin.

Although it is conveniently placed for observation near the center of the lunar disk, Davy Y seems to have received relatively little study from selenographers, who perhaps have been distracted by imposing Ptolemaeus and Alphonsus, nearby to the west. While Davy Y is rather in-



This drawing of the Davy-Palisa region of the moon was made by Alika Herring on May 27, 1958, at 4:15 Universal time, using a 12½-inch reflector with powers of 228x and 310x. As seen from this part of the moon, the sun had risen less than 24 hours before, and was about nine degrees above the horizon. The scale of the key chart is indicated by the diameter of Davy, which is about 21 miles. The largest craterlet in the chain described by Mr. Herring is Davy C, about two miles across. In the standard nomenclature for associated lunar features, mountains are marked with Greek letters, craterlets and other depressions with Roman letters, added to the name of the principal formation.

conspicuous under a high light, at sunrise or sunset its brightly illuminated ramparts and shadowed interior attract the notice of even casual observers.

Davy Y lies on the northwestern edge of what appears to be a vast ancient ghost ring, now almost completely obliterated, one of three such giant rings extending along the western border of Mare Nubium. This chain included the old ring containing the Straight Wall, and the large squarish enclosure in the highlands to the south, often popularly known as the "Hell Plain." This series of ancient rings is well shown on some of the Lick and Mount Wilson photographs of the third-quarter moon.

ALIKA K. HERRING
1312 Arlington St.
Anaheim, Calif.

SUNSPOT NUMBERS

The following American sunspot numbers for January have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

January 1, 234; **2,** 224; **3,** 238; **4,** 213; **5,** 195; **6,** 208; **7,** 233; **8,** 270; **9,** 209; **10,** 181; **11,** 179; **12,** 168; **13,** 133; **14,** 116; **15,** 109; **16,** 146; **17,** 143; **18,** 166; **19,** 165; **20,** 240; **21,** 275; **22,** 234; **23,** 234; **24,** 223; **25,** 256; **26,** 213; **27,** 258; **28,** 242; **29,** 205; **30,** 155; **31,** 114. Mean for January, 199.3.

Below are mean relative sunspot numbers for February by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

February 1, 110; **2,** 139; **3,** 129; **4,** 130; **5,** 126; **6,** 103; **7,** 124; **8,** 90; **9,** 87; **10,** 100; **11,** 100; **12,** 101; **13,** 106; **14,** 129; **15,** 133; **16,** 144; **17,** 170; **18,** 159; **19,** 175; **20,** 150; **21,** 163; **22,** 158; **23,** 186; **24,** 190; **25,** 181; **26,** 176; **27,** 163; **28,** 186. Mean for February, 139.6.

BOOKS AND THE SKY

STELLAR POPULATIONS

D. J. K. O'Connell, S. J., editor. Interscience Publishers, Inc., New York, 1958. 544 pages. $10.00.

WALTER BAADE, in 1943, first proposed the concept of two different stellar populations. This revolutionary idea has played an increasingly important role in astronomical research. Its development from many points of view may be found in papers scattered throughout the various journals. Insofar as the reviewer can determine, the present volume is the first attempt to give all of the various ramifications of the problem in a systematic, comprehensive, and thoroughly coherent manner.

In 1936 the Vatican inaugurated a series of *semaines d'étude,* or weeks of study. These meetings bring together a limited group of leading scholars with divergent opinions on an outstanding question. They spend a week examining the problem, free from all other preoccupations. An attempt is made to formulate the reasons for their differences of opinion, hoping to reach a solution. If agreement is impossible on the basis of the data available, the scholars are called upon to define the reasons why and to specify the types of desirable further research.

This photograph of Dr. Walter A. Baade, retired Mount Wilson and Palomar Observatories astronomer, was taken this January, when he gave a talk on observing with large telescopes to a joint meeting of the Amateur Telescope Makers of Boston and the Bond Astronomical Club. Photograph by Samuel Burgen.

Stellar Populations represents the proceedings of a semaine d'étude in Rome, sponsored by the Pontifical Academy of Science and the Vatican Observatory in May, 1957. A long introduction, in both English and French, details the opening ceremonies, states the conditions and purposes of the conference, and lists the 21 astronomers in attendance.

The scientific portion of the meeting is reported in a series of 34 papers by 18 scientists. Each paper has a transcript of the ensuing discussion, and there is a final section with a summary and conclu-

sions. All reports are in English, except for one French contribution. While they generally read smoothly, the most difficult are those that present extensive technical details of particular methods.

Nevertheless, the volume is exhilarating and the reader does not want to lay it down before arriving at the exciting conclusions. He feels he is listening to the discussions and can sense the mounting excitement of the participants. This effect is generated by the manner in which the discussion of each succeeding paper lengthens as the conference progresses.

The opening report, by Baade, gives a review of the present status of the problem and sets a high standard of excellence for the remainder. The first day of the conference considered the problem of galaxies and their stellar populations. The following days dealt with star clusters, young Population-I stars, physical variable stars, stellar evolution and element abundances, the stellar populations of our own galaxy, population groups and motions in our galaxy, and the galaxy's evolutionary history.

Among the most engrossing talks are A. R. Sandage's masterly discussion of star clusters, M. Schwarzschild's comprehensive summary of the theory of stellar evolution, and G. H. Herbig's account of T Tauri stars. These and the other reports give the feeling that long strides have been taken toward the solution of the problem. We are at last beginning to get a clear picture of the evolution of stars and the nature of stellar populations. The conference clearly points out what has to be done for a final solution.

The Rome meeting concluded by reclassifying stellar populations and defining five basic population types, instead of Baade's original two. These are: Halo Population II, Intermediate Population II, Disk Population, Older Population I, and Extreme Population I (page 287, April, 1958, Sky and Telescope). The conference stressed that the classification system represented a smooth sequence in age, from oldest to youngest. Some stars might fall between the different categories.

Stellar Populations may prove difficult for the layman. But this book should be read by every graduate student in astronomy, teacher, and professional research astronomer. It is an excellent picture of the current state of one of the most fundamental aspects of astronomy. It should stimulate and inspire those working on the problem to tackle the important tasks suggested by the authors.

A short list of errata is included, but the reviewer found many more typographical errors. The printing, format, and paper stock are first class. Unfortunately, the book has a poor binding which cracked and curled after brief use. This is regrettable for a volume that will probably have heavy wear.

ROBERT T. MATHEWS
Goodsell Observatory
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In this book by Allyn J. Thompson are complete step-by-step directions for making and mounting your own 6-inch reflector at low cost. The easy-to-understand chapters tell how to grind, polish, and figure the mirror, and how to make a sturdy equatorial mount to support it. 211 pages, 104 illustrations (6th printing). **$4.00**

POPULAR STAR ATLAS

This compact, well-bound set of 16 maps is a simpler version of Norton's *Star Atlas* (temporarily out of stock). All stars down to magnitude 5½ are included. This edition is excellent for field use by constellation study groups and by meteor parties. **$2.00**

Elger's MAP OF THE MOON

The chart of the moon itself is 18 inches high by 17½ inches wide and identifies all the important lunar features. Below the map are notes by H. P. Wilkins on 146 of the more interesting areas. Printed on a sheet of paper 30 by 19½ inches and mounted on heavy canvas, the map is ideal for framing. **$3.00**

MOON SETS

18 pictures, showing the entire visible face of the moon, are made from unsurpassed Lick Observatory negatives of the first and last quarters. Each halftone print is 8½ by 11¾ inches. Key charts supplied. **$3.00 per set**

LUNAR CRESCENT SETS

10 pictures are a matching series to Moon Sets, but for the waxing crescent 4½ days after new moon, and the waning crescent about five days before new moon. Four prints are close-ups of the waxing crescent, four of the waning; two show each crescent as a whole. Key charts included. **$2.50 per set**

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24 pictures of objects in the solar system and in the Milky Way, all celestial wonders of interest and beauty. Each halftone print is 8½ by 11¾ inches. Separate sheet of captions included. Suitable for study or framing for exhibition. **$4.00 per set**

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24 pictures of nebulae in our galaxy, portraits of other galaxies, many made with the 200-inch telescope, and four drawings of the 200-inch telescope by Russell W. Porter. Sheet of captions included. **$4.00 per set**

SOUTHERN HEMISPHERE CONSTELLATIONS

A 50-page book shows in 12 maps the southern sky as seen from latitude 40° south, for all months of the year. There are extensive notes by the author, Sir William Peck. **$2.50**

LUNAR MAP. In two colors and over 10 inches in diameter. **25 cents each; 3 or more, 20 cents each**

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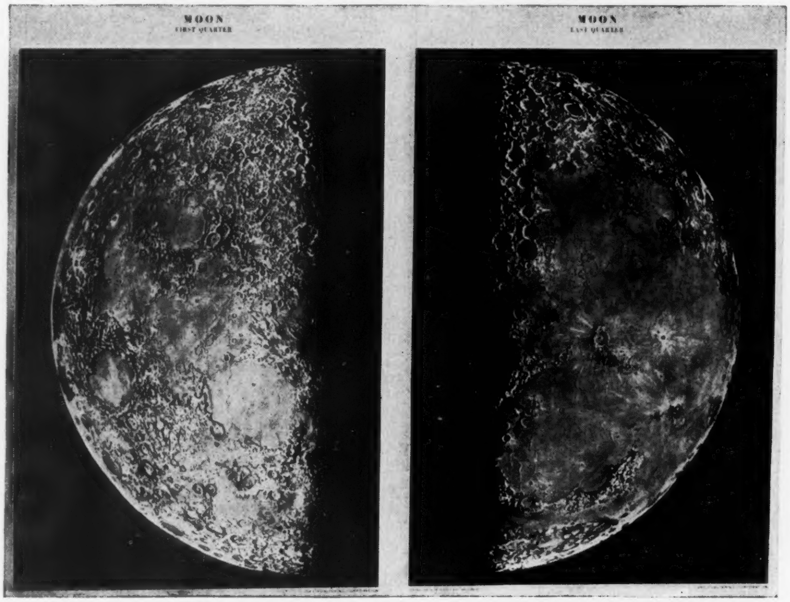
THE STORY OF COSMIC RAYS, by Dr. W. F. G. Swann, Bartol Research Foundation. **75c**

NEW COLOR CHARTS OF THE MOON



These two striking color charts of the first-quarter and last-quarter moon were drawn by Joseph Klepesta, the well-known Czechoslovakian amateur astronomer and astronomical publisher. Each lunar half is an impressive 27 inches in diameter; the over-all size of a chart, 23 inches wide by 33 inches high. Here are two genuinely useful and informative maps for your observatory, library, den, or clubroom. Printed in predominantly gold and black on heavy 150-pound paper, the charts reach you unfolded in a cardboard tube. **$3.00 per set of 2**

Spaceflight

Here is a popular yet authoritative magazine on rockets, astronautics, and space-travel astronomy, written especially for the layman, and edited by members of the British Interplanetary Society. Leading authorities provide a comprehensive coverage of all the fields of science that play such an important part in this thrilling adventure of mankind. Rocketry, space medicine, atomic fuels, radar controls, the exploration of the planets, are all treated in nontechnical language.

Spaceflight is printed during January, April, July, and October. Please specify the issue with which your subscription should start. Back issues to Vol. 1, No. 1, October, 1956, are available.

Subscription in United States and possessions, Canada, Mexico, and Central and South America: $2.50, four issues; $4.50, eight issues; $6.00, twelve issues. Single sample copy, 25 cents.

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ATLAS OF THE HEAVENS

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These 16 charts by Antonín Becvar and his coworkers at the Skalnate Pleso Observatory, Czechoslovakia, cover the entire sky to stellar magnitude 7.75, showing double, multiple, and variable stars; novae, clusters, globulars, and planetaries; bright and dark nebulae; the Milky Way and constellation boundaries.

DE LUXE EDITION. Printed in many colors, more than 35,000 celestial objects, including over 100 radio sources, are plotted. Bayer-letter and Flamsteed-number designations given. Transparent co-ordinate grid overlay included. The 16 charts are permanently bound in a heavy cloth cover, 16½ by 23 inches, with color chart key on a foldout flap. **$9.75**

FIELD EDITION. Each chart is reduced from the original Atlas Coeli and is printed on heavy, stiff paper 18 by 12¼ inches. Stars are white on black background. Charts are shipped flat and unbound, 16 to a set. Ideal for outdoor observing and use at the telescope.

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ATLAS COELI CATALOGUE. Original paper-bound volume with positions for epoch 1950.0. **$5.00**

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L'EXPLORATION DES GALAXIES VOISINES

Gerard de Vaucouleurs. Masson et Cie., 120 Blvd. St.-Germain, Paris 6, France, 1958. 153 pages. 1,600 fr, paper bound.

NO PART of astronomy is more thoroughly astronomical than the study of the external galaxies, associated as they are with the vast extent of observable space, with great spans of time, and with the genesis of the universe. It is also a subject of great popular appeal, involving no formidable mathematics (except in the hands of theoretical cosmologists!). Thus, a book like this can acquaint the nonspecialist reader with a significant frontier of modern science.

Two previous books that have served this purpose well are Hubble's *The Realm of the Nebulae* (1936) and Shapley's *Galaxies* (1943). Gerard de Vaucouleurs' *The Exploration of the Nearby Galaxies* brings the subject up to date and, though limited to the nearer objects, is a good deal more thorough than the other two. Its only drawback for casual American readers is that it is written in French, but this is partially offset by the author's simple, terse style, and by numerous diagrams and photographs.

There was a good deal of updating required to cover advances of the past 15 to 20 years, the most fundamental being the change in the scale of astronomical distances. As de Vaucouleurs shows with great clarity, the distances of the extragalactic nebulae estimated by Shapley and Hubble were all too small by a factor of two to four. This arose partly from an error in the zero point of the period-luminosity relation for Cepheid variables, partly from systematic errors in the scale of apparent magnitudes fainter than 18, and partly from the difference in absolute luminosity between the brightest blue stars of Population I (in spiral arms) and the brightest stars of Population II (mostly red, in globular clusters and elliptical galaxies). It is possible that an even larger correction will be established in the next few years.

Two other major changes in the subject that outdate earlier books are the growth of radio astronomy and rising recent interest in stellar evolution. The author has paid particular attention to the former, summarizing data on both the continuous radio emission and the hydrogen-line emission of our galaxy and the Magellanic Clouds, and discussing the relation between observed optical and radio emission of the "radio galaxies." The hydrogen-line emission at 21-centimeter wave length has already contributed significantly to the "geography" of our galaxy, and it is clear that the continuous emission, associated as it is with violent motions of interstellar gas, has a great deal to offer for study when it is more thoroughly understood.

The book is primarily a summary of observational data: magnitudes, colors, di-

mensions, spectra, rotations, and forms of the nearby galaxies. Dr. de Vaucouleurs himself has made a great many of these observations, and he refers to almost every other recent worker in the field, indicating the year of publication (though unfortunately he neglects to give detailed references to published papers). The 18 plates are of excellent quality; they include several pictures of southern objects taken by the author at Mount Stromlo Observatory, as well as Lick and Palomar photographs, and a useful set selected from the Mount Wilson collection to illustrate the author's 1956 classification of spiral forms (page 582, October, 1957, issue of SKY AND TELESCOPE).

This new morphology requires a three-dimensional plot; to Hubble's simple branching sequence from ellipticals (E0 – E7) to late-type spirals (Sc and SBc) and irregular nebulae, de Vaucouleurs adds another dimension that depends on a ring form. His designations include SB(r)c (open barred spiral with a well-defined ring), SB(s)c (no ring), and intermediate types. These are derived solely from form, unlike a more recent classification scheme employed by Morgan and Mayall based on both form and spectra (page 125, January issue).

THORNTON PAGE
Wesleyan University
Middletown, Conn.

MOON TRIP

William Nephew and **Michael Chester.** G. P. Putnam's Sons, New York, 1958. 63 pages. $2.50.

A COMMON PROBLEM for teachers, librarians, and parents is to find books for children that give reliable facts about spaceflight instead of misinformation or fantasy. *Moon Trip* is a partly successful attempt of this kind for younger teenagers. Both authors are missile engineers who work for the Lockheed Aircraft Corp., and this background has enabled them to make intelligent anticipations about space travel.

Most of their small book is taken up by a simple explanation of rocket principles and a detailed and plausible narrative of a voyage to the moon. This is well done; the writing is clear, and there are no indigestible technicalities. It is the best part of the book, because the authors cover familiar material.

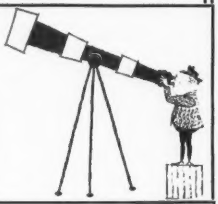
Once on the moon, the authors betray a scanty and inaccurate acquaintance with astronomy. Their definition of a lunar crater as "a circular mountain that is hollow in the middle" is misleading, and to say that the moon was originally "a little sun" of flaming gas does not represent current astronomical ideas.

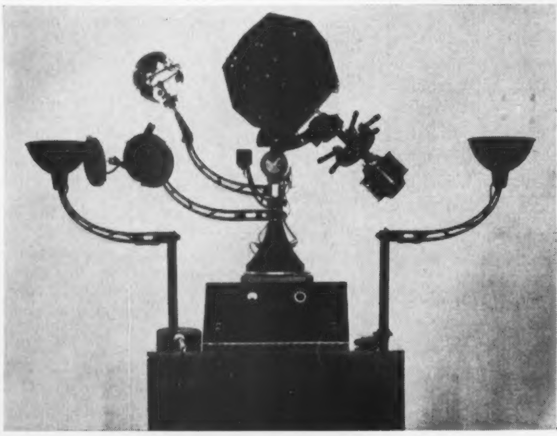
The striking black-and-white drawings are by Jerry Robinson. Strong exception must be taken to the imaginative lunar landscape on the end papers. All the slopes are practically vertical (though none such are known on the moon), there

is a lunar bridge (even though O'Neill's pseudo-discovery is no longer credited), and the artist has drawn the shadows wrong.

This would have been a better book if it had been prepared with a competent astronomer's advice. After all, astronomers have been exploring space with considerable success ever since the invention of the telescope!

MARTHA D. ASHBROOK
Weston, Mass.





NEW BOOKS RECEIVED

A DIPPER FULL OF STARS, *Lou Williams Page,* 1959, *Follett Publishing Co.,* 1010 W. Washington Blvd., Chicago 7, Ill. 223 pages. $2.95.

First published in 1944, this guide for the beginning stargazer has been newly revised and enlarged, including a chapter on man-made satellites.

THE ATOM AND THE ENERGY REVOLUTION, *Norman Lansdell,* 1958, *Philosophical Library.* 200 pages. $6.00.

Atomic power and its applications to industry are described for general readers by a British author, who discusses the physical background, international organizations for the control of atomic energy, and other aspects of the subject.

GUIDE TO THE LITERATURE OF MATHEMATICS AND PHYSICS, *Nathan Grier Parke, III,* 1958, *Dover.* 436 pages. $2.49, paper bound.

Dr. Parke's check list contains the names of over 5,000 books and monographs, listed by subject, to enable physicists, mathematicians, and engineers to find up-to-date reference material.

THE NINE PLANETS, *Franklyn M. Branley,* 1958, *Crowell.* 78 pages. $3.00.

For beginners, each of the principal planets is described in popular language, and information is given on its size, physical characteristics, and orbital motion. The numerous black-and-white drawings are by Helmut K. Wimmer.

TEACHING A UNIT IN ASTRONOMY: GRADES 1-9, *J. Russell Smith,* 1958, *Vantage Press.* 149 pages. $2.75.

A junior-high-school science teacher and well-known Texas amateur astronomer, the author outlines courses in astronomy at the primary, middle-grade, and upper-grade school levels. He includes informative diagrams, star maps, and teaching aid sources for the science instructor.

ASTRONOMY, *Robert H. Baker,* 1959, *Van Nostrand.* 547 pages. $6.95.

This is the seventh edition of the well-known astronomy textbook, which has been extensively rewritten and brought up to date.

RADIOACTIVITY MEASURING INSTRUMENTS, *M. C. Nokes,* 1958, *Philosophical Library.* 75 pages. $4.75.

Although this book is not astronomical, many readers of SKY AND TELESCOPE will be interested in its descriptions of Geiger counters and other devices for detecting radioactivity. General information is given on their construction and circuitry. The terminology is British.

ELECTROMAGNETIC PHENOMENA IN COSMICAL PHYSICS, *B. Lehnert,* editor, 1958, *Cambridge University Press.* 545 pages. $10.00.

Most of the papers collected in this volume were given in August, 1956, at the Swedish symposium on electromagnetic phenomena in cosmical physics. The principal subjects are magnetohydrodynamics, solar electrodynamics, stellar magnetism, solar and interplanetary magnetic fields, and the electromagnetic state in interplanetary space. This was Symposium No. 6 of the International Astronomical Union.

CELESTIAL MECHANICS, *E. Finlay-Freundlich,* 1958, *Pergamon.* 150 pages. $7.50.

Selected topics in celestial mechanics are discussed mathematically in this text for advanced students. Specific applications are given to solar system motions, but the calculation of orbits is not treated.

CERENKOV RADIATION, *J. V. Jelley,* 1958, *Pergamon.* 304 pages. $10.00.

Cerenkov radiation is the faint light produced by charged particles passing through a transparent medium at speeds greater than the speed of light in the medium. This book deals primarily with observations and theory of the Cerenkov effect, and its practical application in particle-detecting devices. Among the astronomical occurrences of Cerenkov radiation discussed are radio emission from sunspots, and light pulses from the night sky caused by cosmic ray particles.

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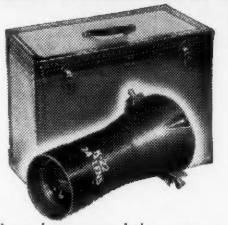

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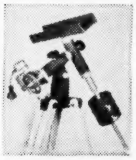

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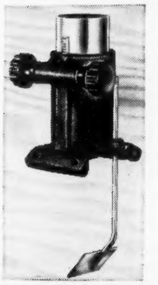

Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment; lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes respectively.

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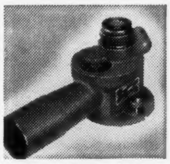

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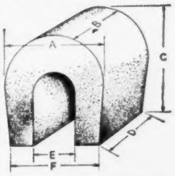

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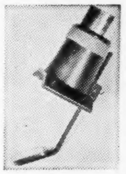

Here is an economical plastic slide-focus eyepiece holder for 1¼" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.........$2.50 ppd.

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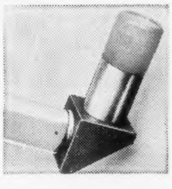

For comfortable viewing of the stars near the zenith or high overhead with refracting telescopes using standard size (1¼" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent quality aluminized right-angle prism. Tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path of the system is about 3½".

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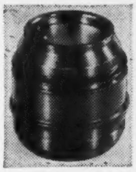

Here is an exciting bargain. We have obtained a large lot of these eyepieces reasonably — so down goes the price to $9.95 for a real sale. Lens system contains 3 coated achromats over 2" in diameter. Gov't. cost over $100.00. Brand new, weight 2 pounds. The value will double when this lot is all sold, and triple and quadruple as years pass. If we didn't need to reduce our inventory, we'd be tempted to hold onto these eyepieces. Their wide apparent field is 65°. The focal length is 1½". Lenses are in a metal cell with spiral threads; focusing adapter with 32 threads per inch is included; diameter is 2-11/16". If you don't order now and you miss out on a hundred-dollar eyepiece for only $9.95, you can't say that we didn't try to impress you with its value. You can make some super-duper finders with these eyepieces. They are also ideal for rich-field telescopes, which are becoming more popular daily, particularly in the Sputnik age. Everyone with a large reflecting telescope should have one of these.

Stock #50,178-Y..................Sale Price $9.95 ppd.

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Sometimes the war-surplus end of this business is heartbreaking. Here is an excellent little telescope that cost Uncle Sam about $200.00. Makes a dandy finder with a 13° field. Weight 2 pounds, size 5¾" x 4½". Objective lens is an achromat, diameter 26 mm., focal length 104 mm. Amici roof prism with faces of 18 mm. x 20 mm. cost from $12.00 to $36.00 to make. Symmetrical eyepiece of 1¼" (32.5 mm.) effective focal length consists of 2 achromats with diameters of 34 mm. and focal lengths of 65 mm.

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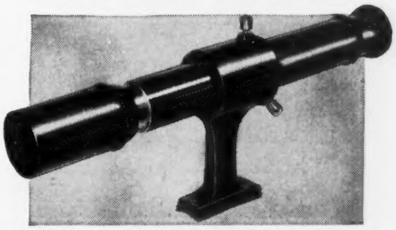

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ pound.

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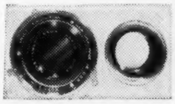

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By Sam Brown. All about various kinds of time, contains sidereal timetable. How to use single- and double-index setting circles, how to adjust an equatorial mount, list of sky objects. Also includes 7" paper setting circles and stripes suitable for cutting out and mounting on plywood. Wonderfully illustrated.

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TESTING LONG-FOCUS CONVEX SPHERICAL SECONDARY MIRRORS

MANY READERS of the SKY AND TELESCOPE *Bulletin A,* describing the construction of off-axis reflectors (December, 1958, issue, page 66), have asked about my method of testing the long-focus convex secondary placed at the upper end of the instrument.

The secondary should be made of optical glass on which the back is ground and polished fairly flat. An accuracy of ½ wave will be sufficient, as during testing the light will be refracted through this surface and not reflected from it. Any of the ordinary optical plate glasses with an index of refraction near 1.5 will do.

To avoid spectrum colors a monochromatic filter must be placed over the pinhole; a light yellow photographic filter is recommended in order not to lose too much illumination.

Refraction through the flat surface, as shown in the diagram, will shorten the path of light when a Foucault or Ronchi test is applied to the convex secondary from the back of the glass. The distance **R′** between the pinhole (or knife-edge) and the back of the secondary will be:

$$\mathbf{R'} = (\mathbf{R} - \mathbf{t})/\mathbf{n},$$

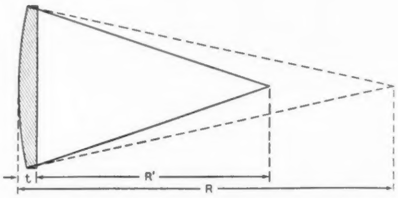
where **R** is the radius of curvature of the convex surface, **t** the axial thickness of the glass, and **n** the index of refraction of the glass.

If optical plate with an index of 1.5 is used, **R′** will closely approximate $\frac{2}{3}$**R**, as the thickness is negligible compared to the radius. This shortening of the path of the rays causes the shadows to stand out very strongly.

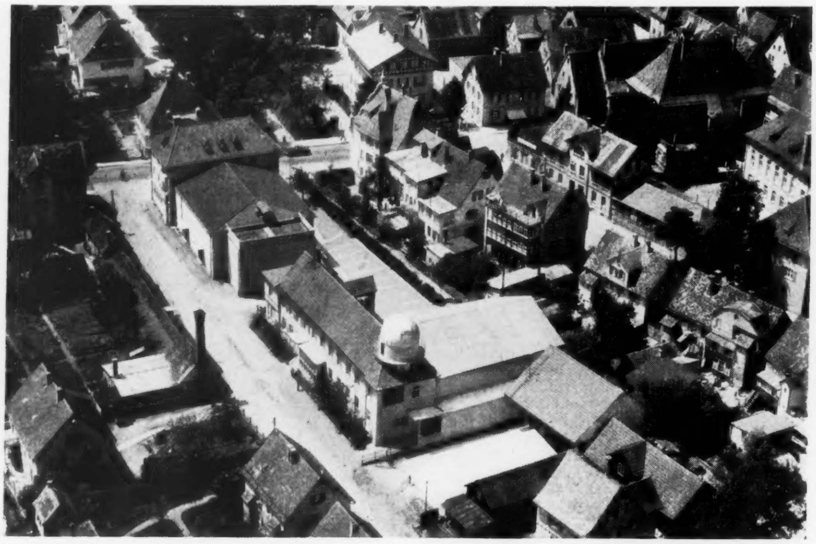
The method is likewise practical in testing the curved surface of the long-radius plano-convex lens used in my catadioptric design. With such a very long radius of curvature, it is recommended that a low-power telescope, 5x to 10x, be installed behind the knife-edge and focused on the test surface.

This method of testing has proved superior to the use of master test plates and interference fringes with monochromatic light.

ANTON KUTTER
Biberach an der Riss
West Germany



The shift in radius, R to R′, caused by testing a plano-convex lens from the back by Mr. Kutter's method.

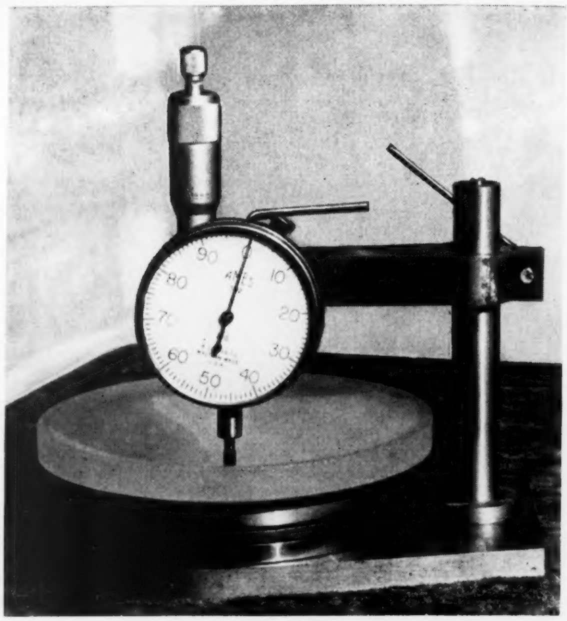


Anton Kutter's observatory at Biberach, West Germany, seen from the air.

Grinding a Maksutov Lens

Inspired by the articles that have appeared in this department on Cassegrainian-Maksutov telescopes, I have made the f/23 design of John Gregory described in March, 1957, page 236. But without a curve-generating machine, there is a great deal of physical work to be done, and a strict check must be kept on the physical characteristics of the corrector lens. Otherwise, one might easily produce a fine prism!

The photographs show my equipment for checking the lens during the grinding stages, by a method that I prefer to the block-micrometer technique suggested by Mr. Gregory. The apparatus is not difficult to make, and it performs the necessary measurements easily.



Right: Fig. 2. The dial indicator is now registering on the concave surface, with any variation in the readings during rotation indicating the amount of wedge existing in the lens. The micrometer spindle behind the dial gauge is not used in this part of the test.

Left: Fig. 1. The correcting lens is being checked at its edge to run true on the ball race in reference to the convex back surface.

I discovered after completing the micrometer stand that the addition of a large ball-bearing thrust race greatly facilitated the testing. Although such races are guaranteed to a high accuracy, they can be checked with the dial gauge. The steep curve and the weight of the glass prevent the lens from slipping on the edges of the rotating race during the test.

First, to make certain that the lens is placed concentrically on the ball-bearing assembly, the dial gauge is set up horizontally and a lever-arm attachment added to its plunger. This is held against the thrust race until the dial-gauge reading remains unchanged as the race turns. Then the

lens is placed convex side down on the race, with the dial-gauge lever in contact with the outside edge of the glass, as shown in Fig. 1. The lens is rotated and adjusted until the dial indicator shows no movement, proving the lens is centered on the race.

The next step is to find out whether the lens is wedge-shaped or not. For this purpose, the vertical indicating shaft of the gauge is placed in contact with the concave lens surface near its edge (Fig. 2). If, as the lens is carefully turned by hand, no movement of the dial needle can be detected, the two surfaces are perfectly concentric. High and low points, on the other hand, are indicated by motion of the needle, and the existing wedge should be corrected by the amount registered on the dial.

Fig. 3. The ring spherometer (left) was employed by Jack Youdale to control the radii of his f/23 correcting lens during grinding. The 0.0001" micrometer spindle head is removable for use at the end of the arm of the jig at the right for measuring central thickness. The ball-bearing race and dial indicator are used with the jig to test for wedge.

As Fig. 3 shows, I have a micrometer head, reading to 0.0001 inch, for measuring the central thickness of the lens, and this is interchangeable with a ring-type spherometer for measuring the radii of curvature of the lens surfaces.

This apparatus enabled me to check radii, lens thickness, and wedging in a most satisfactory manner. The setup is compact, not difficult to make, and is of great value in both the optical and mechanical workshop for many applications by the amateur telescope maker.

JACK YOUDALE
21 Stanhope Rd.
Billingham, Durham,
England

William Davey with the 12½-inch reflector that is mounted in his slide-off-roof observatory. Beneath the edge of the roof near the center of the picture can be seen one of the steps of the stile used to enter the enclosure. The mounting for an 8-inch instrument is housed in the box to the left, the tube being stored in Mr. Davey's home when not in use.

A Roll-off Roof Observatory for a 12½-inch Reflector

SEVERAL YEARS AGO, upon the advice of David P. Barcroft, secretary of the Association of Lunar and Planetary Observers, I obtained a 6-inch mirror and built a tube and mounting for it. Later I bought a Cave 8-inch reflector. With the 6-inch I have often seen the twin craterlets in Plato, and with the 8-inch I once saw the shadow of the wall in Linné on the moon.

When visiting Mr. Barcroft in California, I remarked that I wanted a larger instrument but could not afford an observatory for it. He showed me pictures of simply designed English housings, and on these I based the 10-by-12-foot observatory pictured above. It houses a Cave 12½-inch f/6 reflector (mirror figured to 1/20 wave) with setting circles and a clock drive.

The floor is concrete and the walls are 8-inch cement blocks on a 3-foot foundation. Angle iron provides the track for the sliding roof, secured to the wall with 2-by-8-inch fir planks and bolts sunk in concrete inside the blocks. The uprights at the outer end of the track are railroad ties set in concrete, and outside the building the 2-by-8 fir is double.

The roof moves on six reconditioned barn-door rollers, welded and inserted in 4-by-4 timbers. The bumpers at the track ends are beveled 4-by-4's. The ridgepole is 2-by-6, the roof framing 4-by-4's, with 2-by-4 uprights and rafters. There is a 10-inch overhang, and green asphalt shingles cover ½-inch plywood roof sheathing, providing good weather protection.

The roof has been built to resist wind, yet one man can push it back and forth. To close the observatory, the telescope tube is swung either east or west of the pier and the declination axis is clamped horizontally. The roof is then pushed into position over the walls and fastened with four hook-and-eye bolts and two padlocks.

This observatory is unusual in that it has no doors or windows and has walls just over four feet high. Wall openings were omitted to avoid as far as possible the contact of wood and water (which has seriously warped the housing of the 8-inch instrument). Access to the observatory interior is by means of a sturdy English stile, that is, a ladder on each side of the wall; it is almost all hidden in the picture.

The plywood box at the extreme left contains the pier, equatorial mounting, setting circles, and clock drive for the 8-inch reflector. The box is removed and the telescope tube brought from the house for observing. Electric power for the clock drive is supplied by a battery and converter.

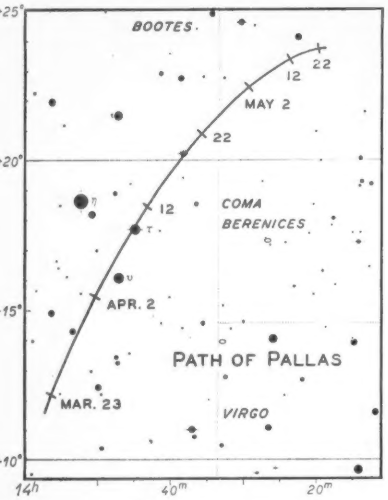
WILLIAM DAVEY
Sky Meadows
Rhinebeck, N. Y.

VARIABLE STAR MAXIMA

April 1, R Virginis, 123307, 6.9; 3, RS Librae, 151822, 7.7; 5, X Centauri, 114441, 7.8; 6, R Cancri, 081112, 6.8; 10, R Draconis, 163266, 7.6; 15, R Geminorum, 070122a, 7.1; 16, V Cancri, 081617, 8.0; 20, R Trianguli, 023133, 6.3; 24, R Canum Venaticorum, 134440a, 7.7; 27, T Ursae Majoris, 123160, 7.9.

May 4, R Reticuli, **043263**, 7.7; 8, T Aquarii, **204405**, 7.9.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.



CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

MINOR PLANET PREDICTIONS

The ephemeris for Pallas is repeated from last month's issue. Both Pallas and Ceres will be bright at opposition, and will be easy objects in binoculars. Finding charts are given here for both of these asteroids.

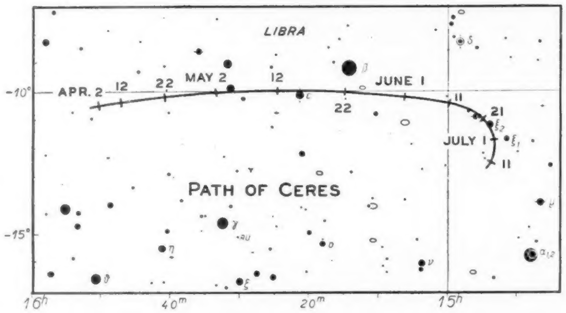
Pallas, 2, 7.6. March 23, 13:56.7 +12-07. April 2, 13:50.6 +15-29; 12, 13:43.3 +18-27; 22, 13:35.6 +20-49. May 2, 13:28.7 +22-29; 12, 13:23.3 +23-28; 22, 13:20.0 +23-51. Opposition on April 17.

Massalia, 20, 9.4. April 2, 14:50.8 −16-18; 12, 14:43.8 −15-43; 22, 14:34.9 −14-58. May 2, 14:25.2 −14-09; 12, 14:16.0 −13-19; 22, 14:08.2 −12-37. Opposition on May 3.

Ceres, 1, 7.3. April 2, 15:50.8 −10-30; 12, 15:47.3 −10-21; 22, 15:41.4 −10-11. May 2, 15:33.5 −10-03; 12, 15:24.4 −9-59; 22, 15:15.2 −10-01. June 1, 15:06.8 −10-12; 11, 15:00.0 −10-33; 21, 14:55.5 −11-03. July 1, 14:53.4 −11-43; 11, 14:53.8 −12-30. Opposition on May 14.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

The paths of two bright asteroids at opposition are shown in these charts from the Skalnate Pleso "Atlas of the Heavens." Pallas (left) reaches magnitude 7.6 in mid-April, while Ceres (right) attains 7.3 a month later.



OCCULTATION PREDICTIONS

April 27-28 **Rho Sagittarii** 4.0, 19:19.3 −17-55.6, 20. Im: **A** 9:02.8 −2.0 −0.3 114; **B** 9:00.4 −1.8 0.0 108; **C** 8:54.7 −2.0 −0.5 122; **D** 8:49.9 −1.7 +0.2 111; **E** 8:30.9 −1.4 +0.1 121. Em: **E** 9:34.0 −1.9 +1.7 227.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard-station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo−LoS**), and multiply **b** by the difference in latitude (**L−LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
	I	+123°.1,	+49°.5		

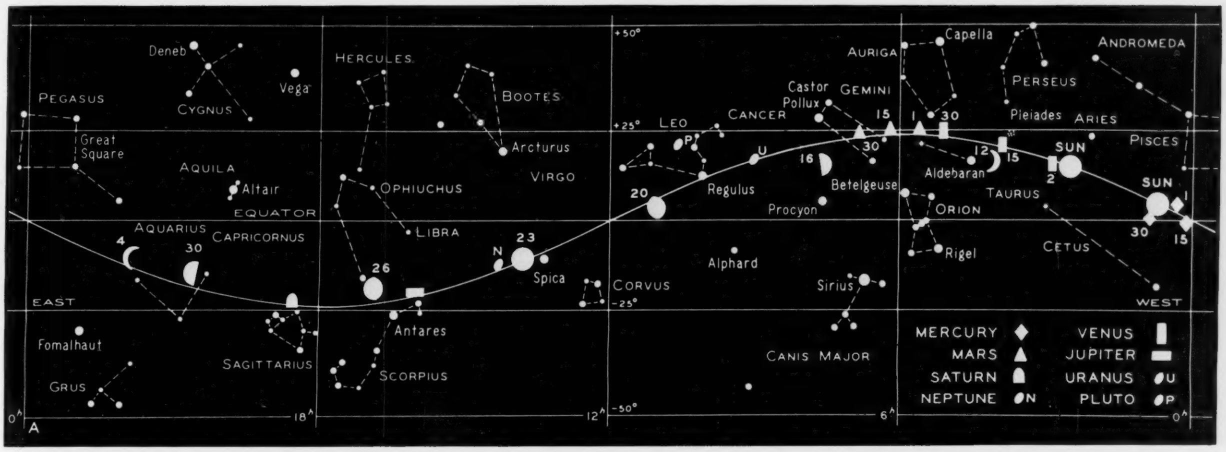
MOON PHASES AND DISTANCE

New moon	April 8,	3:29
First quarter	April 16,	7:32
Full moon	April 23,	5:13
Last quarter	April 29,	20:38
New moon	May 7,	20:11

April		Distance	Diameter
Apogee	10, 23^h	252,400 mi.	29′ 25″
Perigee	23, 18^h	222,200 mi.	33′ 25″
May			
Apogee	8, 4^h	252,600 mi.	29′ 23″

UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other days shown. All positions are for 0^h Universal time on the respective dates.

The sun will be annularly eclipsed on April 8th. The path begins in the Indian Ocean, crosses Australia, and terminates in the Pacific. Maximum duration of the annular phase will be seven minutes, 26 seconds.

Mercury reaches greatest western elongation on the 26th, 27° 11′ from the sun. At that time the planet is of magnitude +0.7 and rises about an hour before the sun, being visible low in the east before sunrise.

Venus sets in the west about three hours after the sun on April 15th. This brilliant object is at magnitude −3.5, and in a telescope shows a gibbous disk 79-percent illuminated and 13″.7 in diameter. On the evening of the 10th the moon will pass about 5° south of Venus.

Mars is a reddish object in western Gemini, at magnitude +1.5 in midmonth. It crosses the meridian about two hours before sunset and sets about midnight, local time, so it is visible in the western sky during early evening.

Jupiter rises about 2½ hours after sunset on the 15th, and is a conspicuous object in Libra for the rest of the night. The giant planet is at magnitude −2.0, and in a telescope its slightly flattened disk is 40″ in polar diameter and 43″ in equatorial. The moon will pass about 3° north of Jupiter on the night of April 24-25.

Saturn rises about local midnight by mid-April. It can be seen low in the southeast as a +0.7-magnitude object in Sagittarius. Telescopes show the planet's disk as 15″.4 in diameter, and the maximum extent of the ring system as 38″. The northern face of the rings is inclined about 26° to our line of sight this year. Saturn will be stationary in right ascension on the 16th, beginning retrograde (westward) motion among the stars. The moon will pass about 4° north of the planet on the morning of the 27th.

Uranus is a 6th-magnitude object in Cancer, crossing the meridian shortly after sunset. On April 15th, its position will be right ascension 8^h $59^m.1$, declination +17° 50′ (1950 co-ordinates). Uranus becomes stationary in right ascension on the 20th, when it resumes eastward motion. Its minute greenish disk, 3″.8 in diameter, can be recognized in fair-sized amateur telescopes.

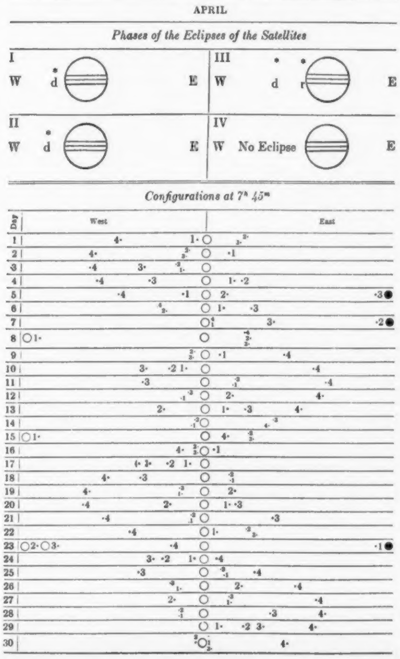
Neptune comes to opposition with the sun on April 26th, when it rises about sunset and remains visible all night as an 8th-magnitude object, 1½° north of the 4.6-magnitude star Lambda Virginis. On that date it is located at 14^h $15^m.2$, −11° 38′ (1950). See page 173, January issue, for finding charts of Uranus and Neptune.

Pluto on April 15th is at 10^h $33^m.7$, +22° 13′ (1950). This 15th-magnitude object is northeast of Gamma Leonis and its co-ordinates change by $-0^m.06$ and +0′.1 each day. Though visible in large amateur telescopes, Pluto is hard to identify. W. H. G.

JUPITER'S SATELLITES

The configurations of Jupiter's four bright moons are shown below, as seen in an astronomical or inverting telescope, with north at the bottom and east at the right. In the upper part, *d* is the point of disappearance of the satellite in Jupiter's shadow; *r* is the point of reappearance.

In the lower section, the moons have the positions shown for the Universal time given. The motion of each satellite is from the dot toward the number designating it. Transits over Jupiter's disk are shown by open circles at the left, eclipses and occultations by black disks at the right. The chart is from *The American Ephemeris and Nautical Almanac.*



APRIL METEORS

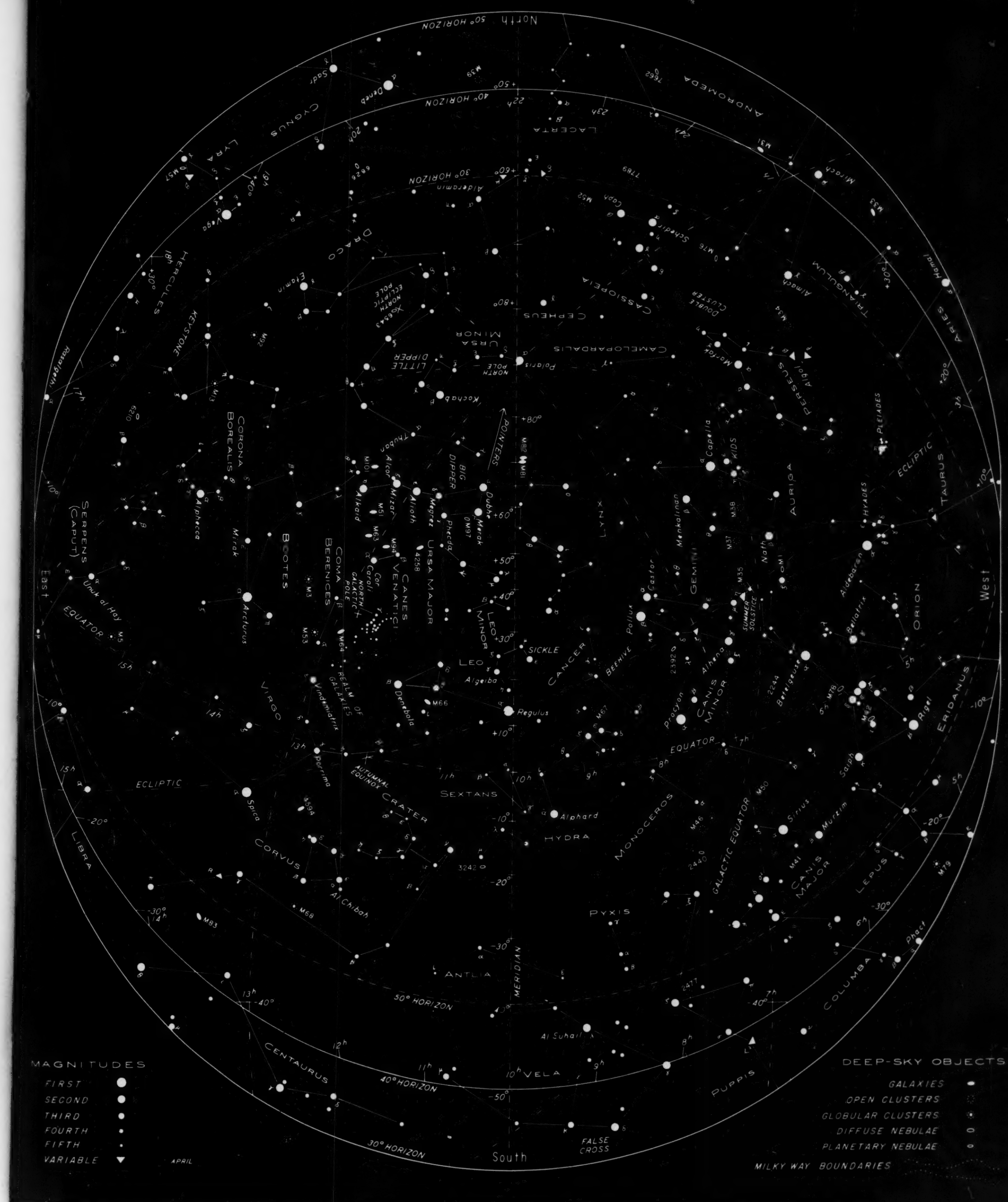
The almost-full moon will interfere seriously with observations of the Lyrid meteor shower, which occurs on the nights of April 20-22 this year. Under more favorable conditions single observers have been able to see a total of about 12 meteors per hour. W. H. G.

MINIMA OF ALGOL

April 2, 13:04; 5, 9:54; 8, 6:43; 11, 3:32; 14, 0:21; 16, 21:10; 19, 17:59; 22, 14:48; 25, 11:38; 28, 8:27.

May 1, 5:16; 4, 2:05; 6, 22:54; 9, 19:43; 12, 16:32.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.



STARS FOR APRIL

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of April, respectively; also, at 7 p.m. on May 8th. For other dates, add or subtract ½ hour per week.

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